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ELISHA MITCHELL Scientific Society

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The Elisha Mitchell Scientific Society

Founded in 1883 through the efforts of Francis Preston Venable

HAROLD HOTELLING, President

J. B. GRAHAM, Vice-President

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Corresponding Secretary

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Volume 65 December 1949 No. 2

PROCEEDINGS OF THE FORTY-SIXTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL, N. C.

The forty-sixth annual meeting of the North Carolina Academy of Science was held at the University of North Carolina on May 6 and 7, 1949.

The Academy convened in a general session at 10:00 a. m. on the first day with President O. C. Bradbury presiding. After the presentation of six papers the session adjourned at noon.

The afternoon session was called to order at two o'clock. After the reading of five papers the session closed and was followed by the business meeting.

The minutes of the 1948 meeting were approved as published in the Journal of the Elisha Mitchell Scientific Society **64**: 147–181. The reports of the various committees were then presented as follows:

REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee met in Durham, N. C., on May 5, 1949, and in Chapel Hill on May 6, 1949. At these meetings the following matters were transacted:

1. The Treasurer was authorized to spend up to $100.00 for secretarial aid.
2. The committee authorized the Treasurer to pay all outstanding bills for operating expenses and to submit his financial report as of July 1, 1949, to the auditing committee.
3. The following were elected to membership in the Academy:

Adkins, Dorothy C., Psychology, University of North Carolina
Anderton, Laura G., Biology, Woman's College U. N. C.
Antonakos, Nicholas, Botany, University of North Carolina
Ardrey, Margaret Martin, Science, Guilford High School
Atchison, Earlene, Botany, University of North Carolina
Barringer, Thomas Smith, Catawba College
Basham, Janet Brooks, Psychology, Duke University
Bell, Clyde Ritchie, Botany, University of North Carolina
Birge, William Root, Psychology, Duke University
Black, Clarence Sigler, Jr., Entomology, N. C. State College

Blanton, Sankey Lee, Jr., Geology, University of North Carolina
Boyce, Steve Gaddy, Forestry, N. C. State College
Boyd, Elizabeth, Mathematics, Greensboro College
Broadhurst, Sam Davis, Geology, N. C. Department of Conservation and Development
Browne, Edward Tankard, Jr., Botany, University of North Carolina
Cohen, Louis David, Psychology, Duke University
Colvin, Ralph Whitmore, Psychology, Duke University
Cook, James William, Elon College
Cooper, William Earl, Plant Pathology, N. C. State College
Costello, Donald Paul, Zoology, University of North Carolina
Cox, Benjamin Franklin, Poultry, N. C. State College
Craig, Frank Rankin, Poultry, N. C. State College
Dai, Bingham, Psychiatry and Psychology, Duke School of Medicine
Deal, Glenn William, Science, China Grove High School
Eller, Frank W., Charlotte College Center
Ellison, William Andrew, U. N. C. Fisheries Research Institute, Morehead City
Evers, John Lawrence, Zoology, N. C. State College
Field, Mrs. Henry R., Science, Gray High School, Winston-Salem
French, R. Carson, Chemistry, Salem College
Galloway, Carl Wilson, Horticulture, N. C. State College
Getzen, James H., Wake Forest College
Glazener, Edward Walker, Poultry, N. C. State College
Gminder, Russell, Catawba College
Gordon, Hiram Landor, Psychology, Duke University
Gordon, Morris Aaron, Botany, Duke University
Hackney, Edward June, Chemistry, Duke University
Hall, William Gardner, Catawba College
Hamilton, Dorothy Elizabeth, Psychology, N. C. Department of Public Welfare
Hammons, Ray O., Agronomy, N. C. State College
Hamrick, Marietta, Biology, Gardner-Webb Junior College
Harpster, Hilda T., Biology, Woman's College U. N. C.
Heck, Landon Carroll, Physics, Catawba College
Hester, William, Psychology, Duke University
Hoke, Owen Heller, Mathematics, University of North Carolina
Hudson, A. E. A., Biochemistry, N. C. State College
Jenkins, Charles Ross, Jr., Psychology, Duke University
Jones, Ora Melinda, Psychology, Duke University
Keever, Nancy Catherine, Botany, Duke University
Kirk, D. E., Botany, University of North Carolina
Klemm, Ethel Mina, Science, Warren Wilson College
Lancaster, Eloise, Agronomy, N. C. State College
Lehman, H. Eugene, Zoology, University of North Carolina
McKeever, Sturgis, Zoology, N. C. State College
McKinley, Glenn Ernest, Geology, N. C. State College
Macon, Nathaniel, Mathematics, University of North Carolina
Marshall, Roy K., Astronomy, University of North Carolina
Miller, Harry Brown, Chemistry, Wake Forest College
Miller, William Knight, Chemistry, University of North Carolina
Nowell, John William, Chemistry, Wake Forest College
O'Connell, J. Elbert, Biology, Wake Forest College
Osborne, Elizabeth M., Biology, Woman's College U. N. C.
Pack, Albert Boyd, Botany, N. C. State College
Pendergrass, William R., Botany, University of North Carolina
Pope, Hilda Persons, Bacteriology, Duke School of Medicine

Powell, William Allen, Chemistry, Wake Forest College
Rice, Lucile Addie, Biology, East Carolina Teachers College
Robinson, Joe, Elon College
Rodgers, Charles L., Botany, University of North Carolina
Roe, Arthur, Chemistry, University of North Carolina
Schuler, Anne Warren, Physics, Woman's College U. N. C.
Schulz, Henry Louis, Liggett and Myers Tobacco Co., Durham
Stinetorf, Roscoe, Mathematics, Catawba College
Thomas, Annabelle, Biology, Woman's College U. N. C.
Thompson, Anne Elizabeth, Entomology, N. C. State College
Townes, Henry K. Jr., Entomology, N. C. State College
Townes, Marjorie Chapman, Raleigh
Trott, John, Jr., Children's Nature Museum, Charlotte
Tucker, Irwin William, Liggett and Myers Tobacco Co., Durham
Turkel, Henry, Physician, Detroit, Michigan
Wheeler, Robert James, Jr., Wildlife Resources Commission, Raleigh
Williams, J. Paul, Chemistry, University of North Carolina
Williams, Ruth Margaret, Psychology, Duke University
Wright, Paul Gordon, Biology, Wilmington College
York, M. A., Raleigh
Yost, Basil Otto, Elon College
Youngs, Lillian Margot, Biology, Catawba College

4. The following were reinstated as members in the Academy:

Brannon, Clarence H., Entomology, N. C. State Department of Agriculture
Coldwell, E. Inez, Biology, Woman's College U. N. C.
Crockford, Horace Downs, Chemistry, University of North Carolina
Ferguson, John Howard, Physiology, University of North Carolina School of Medicine
George, Wesley Critz, Anatomy, University of North Carolina School of Medicine
Love, Lila Belle, Biology, Woman's College U. N. C.
Miller, Edwin Lawrence, Jr., Geology, N. C. State College
Parker, John Mason III, Geology, N. C. State College

5. The Secretary reported the following losses in membership:

1. By resignation: 2
2. By non-payment of dues: 18
3. By death the following:
   William John Dann
   Albert Harvey Grimshaw
   Harvey Burnell Ohmer
   William Wilson

6. The Committee accepted the invitation of the Woman's College of the University of North Carolina to meet in Greensboro in 1950.

The above reports of the Executive Committee were adopted by the Academy.

TREASURER'S REPORT

Financial Statement as of July 1, 1949

Receipts

Bank balance (from July 1, 1949)	$65.92
Gift	
A. A. A. S. Research Grant, 1949	74.50

Dues, 1948	9.00
Dues, 1949	538.00
Dues, new members and reinstatements	186.00
Total	873.42

Expenditures

Elisha Mitchell Scientific Society	300.00
Secretarial aid	80.00
W. B. Fox and R. K. Godfrey (A. A. A. S. Research Grant)	74.50
Secretarial commission	70.00
Stationery, printing and programs (N. C. State Print Shop)	50.55
Postage and stamped envelopes	49.96
Academy Awards	25.00
Waverly Press (reprints)	14.70
A. D. Shaftesbury (postage, High School Committee)	14.50
Piedmont Press (printing, High School Committee)	8.50
Bank charges	4.34
Expenses to meeting	3.00
Office supplies	2.73
Total	607.78
Bank balance	173.64
Cash on hand	2.00
	873.42

Savings Account

Balance July 1, 1949	66.53

Total Assets

Checking account and cash on hand	175.64
Savings account	66.53
U. S. Savings Bonds (maturity value)	300.00
Total	542.17

On the first day of July, 1949, we, the undersigned, have examined this account and found it to be correct.

(Signed) F. S. BARKALOW, JR.
BEN W. SMITH
J. M. CLARKSON, *Chairman*.

REPORT OF THE LIFE MEMBERSHIP COMMITTEE

The committee, consisting of G. H. Satterfield, J. N. Couch, Maude Williams, and H. J. Oosting, in accordance with the rules governing life membership which were established in 1943, recommended that the following persons be elected to life membership:

Hugo Leander Blomquist, Botany, Duke University
John Paul Givler, Biology, Woman's College U. N. C.
William Woodrow Martin, Psychology, Woman's College U. N. C.

The Academy unanimously elected these scientists to life membership.

REPORT OF THE RESEARCH GRANTS COMMITTEE

The award for the past year was given to Dr. E. C. Cocke of Wake Forest in support of his survey of the Myxophyceae of North Carolina. The committee, now consisting of O. C. Bradbury, B. W. Wells, W. O. Puckett, and A. D. Shaftesbury, received three applications for the 1949 A. A. A. S. grant. After due consideration it was decided to present the grant to Dr. W. B. Fox and Mr. R. K. Godfrey of N. C. State College. They will use the grant of $74.50 for partial defrayment of expenses incurred in a study of the Leguminosae and Compositae of North Carolina.

E. C. COCKE
G. R. MACCARTHY
W. O. PUCKETT
B. W. WELLS, *Chairman.*

REPORT OF THE POTEAT AWARD COMMITTEE

The committee met at noon on Saturday, May 7, 1949, and discussed at length the difficult problem of selecting a meritorious paper presented this year. After due consideration it was decided to grant the award to Miss Nancy Catherine Keever for her excellent paper, "Causes of succession on abandoned fields in the Piedmont of North Carolina."

K. L. BARKLEY
D. S. GROSCH
W. L. HAMNETT
REINARD HARKEMA
H. V. PARK
MARY E. YARBROUGH
LEWIS E. ANDERSON, *Chairman.*

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE

Dr. A. D. Shaftesbury, Chairman of the committee, informed the Academy that no essays were received to compete for the Ornithology and Forestry Awards. Announcement was made at the evening meeting of the following winners of exhibit awards:

THE ACADEMY AWARD

First Prize: Henry Yancey, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Water Purification."

Second Prize: David Sims, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Materials for Electromagnetic Radiation."

Third Prize: Roderick Reid, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Rockets."

BIOLOGICAL EXHIBITS AWARD

(Carolina Biological Supply Company)

First Prize: Dave Adams, Central High School, Charlotte; Frank W. Eller, Sponsor.
"Representative Mammals."

Second Prize: Tenth Grade Biology Class, Black Creek High School; Mrs. Will Rhodes, Sponsor.
"Biology Exhibit."

Third Place: Tommy Thompson, New Hanover High School, Wilmington; P. G. Wright, Sponsor.
"Preserved Specimens."

REPORT OF THE CONSERVATION COMMITTEE

Last year the Committee reported on the forestry situation in North Carolina. The report was dressed up by Dr. W. Amos Abrams, Associate Editor of *North Carolina Education*, under the catchy title "Our Forest Follies," and together with a photograph was published in that journal. This periodical reaches most of the teachers in the State. One thousand reprints of the report were obtained and requests quickly exhausted the supply, except for a few copies which were withheld.

This year we are submitting a report on the North Carolina resource-use education program. The Academy members are somewhat familiar with the character of the program in that the program director has given papers at the last two annual meetings.

The program has been sponsored by the North Carolina Resource-Use Education Commission which was appointed by the Governor in 1948. It is composed of representatives of 46 state agencies, professional, scientific, and educational organizations. Dr. F. G. Hall, our past President, represents the Academy on the commission. The program Director, Dr. Richard Weaver, has been employed by the Commission since February 1947, with headquarters here in Chapel Hill on funds supplied by the General Education Board. As of July 1 this year, Dr. Weaver will become a member of the staff of the State Department of Public Instruction with headquarters in Raleigh. A consultant in resource-use education, Mr. Homer Lassiter, has also been added to the staff as of May 1 through a special contract with the Tennessee Valley Authority.

The Commission was organized and the staff was charged with the responsibility for:

(1) Channeling more scientific information about resources into the school program.
(2) Making greater use of the resource agencies, materials, and staff in the educational program of the State.
(3) Developing projects and plans which would help teachers and colleges make education deal more directly with the problem of living, the development of communities, and the sound management of resources.

Eight area centers were organized at the following institutions:

Appalachian State Teachers College, Boone, N. C.—Chairman, Julian C. Yoder
East Carolina Teachers College, Greenville, N. C.—Chairman, Leo W. Jenkins
Elizabeth City State Teachers College, Elizabeth City, N. C.—Chairman, President S. D. Williams
North Carolina College, Durham, N. C.—Chairman, Theodore R. Speigner
Shaw University, Raleigh, N. C.—Chairman, President Robert P. Daniel
Saint Augustine College, Raleigh, N. C.—Chairman, President Harold L. Trigg
Western Carolina Teacher's College, Cullowhee, N. C.—Chairman, W. B. Harrill
Woman's College, University of North Carolina, Greensboro, N. C.—Chairman, Dennis H. Cooke

A faculty committee, an area committee composed of representatives of resource agencies and the public schools in the area, developed programs and projects for each area. Ten or more schools in each area agreed to be participating schools to develop special resource-use programs.

Area conferences and summer workshops have been held at these centers where school people have worked with scientists and resource technicians to determine what information about resources should be included in the school program, and which techniques are most successful. Two hundred fifty teachers were enrolled in five resource-education workshops held last summer at Boone, Greensboro, Greenville, Cullowhee, and Brasstown.

This year workshops will be held at Boone, Greenville, Elizabeth City, Salisbury (Catawba College), and at Raleigh where North Carolina College, Shaw University and Saint Augustine's College are cooperatively sponsoring one workshop on the campus of Saint Augustine's.

A Guide on Resource-Use and a State Directory of Resource Agencies is nearly completed, which will assist teachers, college staff members and others in developing a greater emphasis on the use, conservation, and management of all of our resources.

Special guides on forestry, wildlife, agriculture, soil conservation, minerals and geology, water, and industry are being considered by the various State agencies responsible for these resources.

Films, radio programs, and demonstrations are needed and will be provided as rapidly as possible.

Academy members can assist in the expansion of this important program in many ways such as:

(1) More emphasis is needed in all the colleges and in most of the science courses on the development and wise use of our resources, particularly those in which future teachers are enrolled. These teachers need to know more about the wealth of resources in North Carolina, the ways to manage and develop these resources, the best techniques for studying them, the sources of information, and help through the state and federal agencies and private organizations.

Field trips, contact with resource personnel, individual field research and observation, greater use of visual materials and local data are some of the ways this instruction can be made more effective.

(2) Organization of resource-use workshops on campuses for teachers and undergraduates where information on each of the resources is available, but also

where the interrelation and interdependence of the plants and animals, soils, water, and minerals can be illustrated, and where the development of these can be oriented toward the improvement of living, the raising of the economic level, the greater provision for food, shelter, clothing, recreation, and the cultural needs of people.

(3) Make yourself available to city and county school systems and the resource-use area centers for consultant help to discuss the results of your research, and to advise on the special problems of resource management in your special interest field.

(4) Help popularize the new research findings through articles for educational journals and talks to adult groups.

(5) Assist in the practical research needed in those fields where communities need special help, such as combating stream pollution, development of parks, scenic areas, wildlife sanctuaries, demonstration areas, interesting new types of industries in your city or town, developing new markets and products for the maximum use of the resources in your region.

Conclusions

While teaching the principles of science and engaging in scientific research we should endeavor to seek out and stress the practical applications so that North Carolina with its wealth of natural resources, people, agencies and institutions can provide a richer, fuller and more abundant life for all its people.

The Academy of Science, through its members, can provide the leadership and initiative at the various educational centers to develop a greater emphasis on resource-use education and to help in the important job of training our future teachers in the values and techniques of wise resource management and use.

ARTHUR STUPKA
R. L. WEAVER
C. F. KORSTIAN, *Chairman*.

The above report was approved by the Academy.

REPORT OF THE LEGISLATIVE COMMITTEE

Nothing was brought to the attention of the Legislative Committee during this year. Several persons were contacted to discover if any matters should be looked into, but there were none.

B. W. WELLS
H. F. PRYTHERCH
Z. P. METCALF, *Chairman*.

The above report was accepted as information by the Academy.

REPORT OF THE RESOLUTIONS COMMITTEE

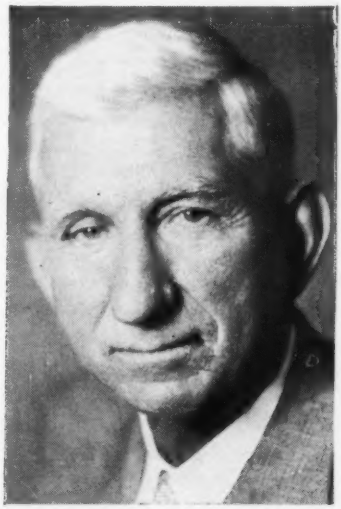
Be it resolved that the North Carolina Academy of Science is deeply appreciative of the hospitality, entertainment, and courtesies extended to its members by

Chancellor R. B. House, the Faculty, and students of the University of North Carolina; and that the especial appreciation of the Academy is due the local Committee on Arrangements for its part in making this, its forty-sixth annual meeting, successful and enjoyable.

Be it further resolved that a copy of this resolution become a part of the minutes of the Academy, and that copies be sent to Chancellor R. B. House and to Dr. J. N. Couch, Chairman of Committee on Arrangements.

O. J. THIES.

The above resolution was unanimously approved by the Academy.



REPORT OF THE SPECIAL COMMITTEE ON THE JOHN BEWLEY DERIEUX MEMORIAL AWARD

PART I

Whereas, Mrs. Elizabeth Tipton Derieux has expressed the wish to establish within the North Carolina Academy of Science a memorial to her late husband, Dr. John Bewley Derieux, in the form of an annual award for the best essay submitted by a college student on a topic in the field of Modern (or Contemporary) Physics, be it resolved:

First, that the Academy gratefully accept the offer to establish this memorial award as a fitting tribute to the long period of faithful service to the Academy and the active interest which Dr. Derieux displayed at all times in the activities of the Academy.

Second, that the award be known as the John Bewley Derieux Memorial Award.

Third, that this Award be included as an annual activity of the Academy for the purpose of stimulating interest among college students in pursuing further study in this field of learning.

Fourth, that, in accordance with the wishes of the donor, the Award be fifty dollars in cash and an inscribed certificate of the Award for the best essay by a North Carolina college student on a topic in the field of Modern (or Contemporary) Physics.

Fifth, that these resolutions be made a part of the minutes of the Academy, that the Secretary of the Academy supply the press of the State with notice of the establishment of the Award, and that a copy of these resolutions be transmitted to the donor of the Award.

W. E. SPEAS
OTTO STUHLMAN, JR.
J. S. MEARES, *Chairman.*

The above report was unanimously approved by the Academy

PART II

To activate the John Bewley Memorial Award the Committee makes the following recommendations:

1. That the President of the Academy annually appoint a committee to judge the essays and report the name of the award winner to the Academy at its annual meeting.
2. That the Secretary of the Academy be responsible for implementing the Award by giving due publicity in the colleges, in the State of North Carolina, concerning the Award by October first of each year.
3. That an eligible participant be any regularly enrolled undergraduate student in any college or university in North Carolina.
4. That the essay may have any specific title within the general area currently referred to as Modern Physics (or, the general area of contemporary developments in Physics during the past ten years).
5. That the essay be typewritten on $8\frac{1}{2}''$ x $11''$ size paper, double-spaced, with one-inch margins, and not exceeding 3,000 words in length (excluding illustrative material).
6. That the local college staff, in the departments of origin of the essays, examine the entries of its students and submit not more than the best two essays to the Secretary of the Academy at least six weeks prior to the annual meeting of the Academy.
7. That in competing for this Award the candidate accepts the recommendation of the judging committee as final.
8. That the judging committee be empowered to recommend that no award be made in any year when the members unanimously agree that no entry meets a reasonable standard of excellence worthy of the Award.
9. That the Secretary of the Academy be responsible for issuing the engraved

Certificate of Award in cooperation with the Donor. The Donor agrees to assist in the design of the certificate and to finance its engraving.

W. E. SPEAS
OTTO STUHLMAN, JR.
J. S. MEARES, *Chairman.*

The above recommendations were accepted by the Academy.

The following memorial reports were presented at the meeting:

WILLIAM JOHN DANN

Dr. William John Dann was born in Bath, England, November 9, 1904. He received the B.S. degree from the University of Sheffield in 1925 and the Ph.D. degree from Cambridge University in 1932, where he received training from Sir Frederick Gowland Hopkins, internationally known scientist and Nobel laureate. Dr. Dann was awarded the Doctor of Science degree in 1943 by his alma mater, the University of Sheffield, a very high honor. Dr. Dann came to Duke University in 1934 as a Beit Memorial Fellow. He was appointed assistant professor and subsequently associate professor and in 1945 professor of nutrition in the Medical School of Duke University. He died on December 5, 1948, after an illness of several months.

Dr. Dann exerted a forceful influence in the field of nutrition. He was a true experimentalist with a clear and precise mind. His earlier contributions dealt with the physiology of vitamin A, especially as related to placental transfer. His later researches were in the field of niacin in foods. He described many methods for vitamin determinations and under his editorship the very valuable symposium "Estimation of Vitamins" was published. He served for many years on the editorial staff of the Nutrition Reviews.

John Dann was a modest man who profoundly influenced his associates. He encouraged frank and honest discussion. He was at times impatient with confused and emotional thinking, but he was always generous. He held to liberal views and was acutely aware of the social responsibilities of science and of nutrition in particular.

Our science is poorer because of the loss of W. J. Dann. The North Carolina Academy of Science will miss this steadfast scientific leader. His associates at Duke University are greatly saddened by the departure of so true and noble a friend.

F. G. HALL.

The above memorial was approved by a rising vote.

ALBERT HARVEY GRIMSHAW

Professor Albert Harvey Grimshaw, member of the faculty of the School of Textiles at North Carolina State College for 24 years, died in Raleigh on April 20 following a period of ill health, but as the immediate result of a heart attack.

A native of Providence, Rhode Island, he received his undergraduate education at the Textile Institute of New Bedford, Massachusetts, and North Carolina State College. He received the Bachelor of Science degree from State College in 1927 and the Master of Science degree in 1935. He also attended the Massachusetts Institute of Technology and Columbia University for special training. He was a registered pharmacist, and operated a pharmacy in New Bedford from 1916 to 1925, and for a part of that time acted as head of the Department of Chemistry and Dyeing at the Textile Institute.

He came to North Carolina State College in 1925, and was head of the Department of Chemistry and Dyeing for many years, retiring from that position several months ago. He was active in research in the field of textiles and was a very prolific writer, contributing to most of the textile journals in this country.

In addition to his affiliation with the North Carolina Academy of Science he was a member of the American Association for the Advancement of Science, the American Institute of Chemists, and the American Association of Textile Chemists and Colorists. He was a member of Phi Kappa Phi, Sigma Tau Sigma, Delta Kappa Phi and Gamma Sigma Epsilon. The State College chapter of Gamma Sigma Epsilon recently presented a portrait of him to the College, where it now hangs in the School of Textiles.

He is survived by his widow, by a son, Dr. Albert Grimshaw of the University of Illinois, a sister, Miss Margaret Grimshaw of Somerville, Massachusetts, a brother, Mr. Ralph Grimshaw, of Cleveland, Ohio, two grandchildren and one great grandchild.

T. B. MITCHELL.

The above memorial was approved by a rising vote.

HARVEY BURNELL OHMER

Mr. Harvey Burnell Ohmer, member of the North Carolina State College faculty, died in Baltimore, June 26, 1948, after a short illness.

He was born February 10, 1910, in St. Clair County, Michigan, near the town of Yale, and was educated at Yale Public Schools, Port Huron Junior College, and Michigan State College, where he received his B.S. degree in Chemistry in 1934. Having been awarded a fellowship in chemistry he returned to Michigan State College for the following two years and obtained his M.S. degree in 1936, in the fields of biological chemistry and bacteriology. From 1936 to 1942, he was in charge of chemistry at Port Huron High School, Port Huron, Michigan. The summers from 1937 to 1941 were spent in bacteriological research at Faison, North Carolina, on commercial cucumber fermentations in connection with the cooperative project between the North Carolina Agricultural Experiment Station, the U. S. Department of Agriculture, and the Chas. F. Cates Company. It was in this capacity that he made important contributions to the research program in commercial brine fermentations and development of the pasteurization procedure now so widely used in the pickling industry.

From 1942 to 1946, he served in the U. S. Army as a First Lieutenant in the

Chemical Warfare Service, and taught toxicology at Edgewood Arsenal. For two years he was in charge of the Toxicological Research Laboratory. Mr. Ohmer came to North Carolina State College in 1946, and was a member of the Chemistry Department until his untimely death. In the brief period of two years, he earned a reputation as an outstanding teacher; one who enjoyed teaching and the opportunity to work with students. He had that rare gift of human understanding, and it could be said that helping others was his hobby. In addition to his teaching duties, he had completed most of the requirements for his doctorate. Just a few days before his death he had isolated a number of cultures of halophilic bacteria responsible for a new type of gaseous fermentation in cucumber brines.

He was a member of the Society of American Bacteriologists, North Carolina Society of Bacteriologists, Alpha Chi Sigma, professional chemical fraternity, Sigma Alpha Beta, honorary bacteriological fraternity, and the North Carolina Academy of Science. His church affiliation was with the First Presbyterian Church, Raleigh, North Carolina.

Surviving are his widow, Mrs. Helen Taylor Ohmer of Raleigh, North Carolina, two brothers and two sisters: Charles of Yale, Michigan, and Henry of Saginaw, Michigan, Mrs. Timothy Cook of Yale and Mrs. Holland Whitney of St. Louis, Michigan.

T. A BELL
J. L. ETCHELL
G. H. SATTERFIELD.

The above memorial was approved by a rising vote.

WILLIAM WILSON

William Wilson, Professor of Physics at North Carolina State College, died at Rex Hospital in Raleigh on May 6, 1948. He is survived by his wife, the former Ada M. Edlin, and three sons: William, David, and Stephen Wilson.

Dr. Wilson was born at Preston, England, March 29, 1887, and attended the public schools there. He studied under the great Lord Rutherford at the University of Manchester in England, from which he received the B.Sc. degree in 1907, the M.Sc. degree in 1908, and was awarded the D.Sc from this institution in 1913. In the meantime, he did research under the eminent physicist Sir J. J. Thompson at Cambridge University from which he received the B.A. degree in research in 1912. During the above period he published numerous papers in the field of radioactivity, the more important results of which are given in Rutherford's book, "Radioactive Substances and their Radiations."

In 1912 Dr. Wilson came to Canada as Lecturer in Physics at the University of Toronto, where he remained until 1914. From 1914 to 1942 he was with the Research Department of the Western Electric Company and the Bell Telephone Laboratories in New York. During this period he held a number of important positions with the Laboratories such as: Assistant Director of Research, Director of Vacuum Tube Research, Director of Radio Research, Director of Wire

Transmission Research, and Assistant Vice-President of the Laboratories. While at the Laboratories he published a number of papers in the field of radio and wire telephony. He was a Fellow of the American Physical Society, the American Institute of Electrical Engineers, the American Association for the Advancement of Science, the Institute of Radio Engineers, and a member of the Union Scientifique International de Radio. He served on many important committees, both national and international, of the various societies with which he was affiliated. In 1943 the Institute of Radio Engineers conferred on him one of its highest awards, the Medal of Honor.

Due to a heart ailment Dr. Wilson retired from the Bell Laboratories in 1942, but after a rest of two years returned to the teaching profession. He was at the Phillips Exeter Academy from 1944 to 1946. In September, 1946, he joined the Physics Department Staff at State College and during the year became a member of the North Carolina Academy of Science.

During his relatively short period of service in North Carolina Dr. Wilson won the deep respect and admiration of his associates and students through his warm personality, scholarly attainments, broad interests, and human understanding. We wish hereby to express our deep feeling of loss in the passing of this able adviser, scholar, and friend.

J. S. MEARES.

The above memorial was approved by a rising vote.

REPORT OF THE NOMINATING COMMITTEE

The Committee, consisting of M. L. Braun, Chairman, H. L. Blomquist, and R. E. Coker, submitted the following nominations:

President: C. F. Korstian, Duke University
Vice-President: W. O. Puckett, Davidson College
Secretary-Treasurer (3 years): Reinard Harkema, N. C. State College
Member of the Executive Committee: C. H. Bostian, N. C. State College
Member of the Research Grants Committee: A. D. Shaftesbury, Woman's College U. N. C.

There being no nominations from the floor, the Secretary was asked to cast the ballot and declare the nominees elected. This concluded the business and the meeting was adjourned.

At 6:00 p.m. the membership enjoyed a complimentary dinner given by the University of North Carolina. Vice-president P. J. Kramer presented Chancellor R. B. House of the University of North Carolina, who welcomed the Academy to the Campus. At 8:00 p. m. the evening session was held in Gerrard Hall. After announcing the winners of the High School Awards, Dr. P. J. Kramer presented the President of the Academy, Dr. O. C. Bradbury. Dr. Bradbury's Presidential Address was entitled, "Some Ecological Phases of a Prairie Region with Special Reference to Insect Ecology."

All of the sectional meetings were held on Saturday morning. These were well attended. The following officers were elected for the respective sections:

Biochemistry and Physiology: Chairman, G. C. Kyker; Secretary, Marjorie Swanson.
Botany: Chairman, L. A. Whitford; Secretary, L. E. Anderson.
Geology: Chairman, H. T. Davis; Secretary, E. W. Berry.
Mathematics: Chairman, Whitfield Cobb; Secretary, A. V. Coble.
Psychology: Chairman, Karl Zener; Secretary, Marion Stanland.
Wildlife: Chairman, T. L. Quay; Secretary, W. L. Hamnett.
Zoology: Chairman, A. D. Shaftesbury; Secretary, D. S. Grosch.

The following constitute the personnel of the standing committees:

Executive: C. F. Korstian, W. O. Puckett, Reinard Harkema, I. E. Gray, A. F. Thiel, C. H. Bostian.
Research Grants: O. C. Bradbury, B. W. Wells, W. O. Puckett, A. D. Shaftesbury.

Dr. C. F. Korstian, President of the Academy for 1950, announced the appointment of the following committees:
Auditing: J. M. Clarkson, B. W. Smith, F. S. Barkalow, Jr.
Conservation: R. L. Weaver, F. S. Barkalow, Jr., W. D. Miller, H. J. Oosting.
High School: Ruth M. Addoms, J. H. Highsmith, M. W. Johnson, H. S. Roberts, Jr., Ruby Williams.
Legislative: F. G. Hall, J. L. Stuckey, H. L. Blomquist.
Life Membership: J. N. Couch, Maude Williams, W. L. Porter.
Nominating: O. C. Bradbury, M. L. Braun, F. G. Hall.
Poteat Award: L. E. Anderson, E. W. Berry, A. V. Coble, D. S. Grosch, W. L. Hamnett, Reinard Harkema, Marion Stanland, Marjorie Swanson.
Resolutions: E. T. Browne.
Representative on A. A. A. S. Council: John N. Couch.
Representative to Academy Conference: Reinard Harkema.
Constitution: H. R. Totten, H. L. Blomquist, Reinard Harkema.

Approximately 400 members and guests registered during the meeting.

The following papers were presented during the meeting. Those marked with an x are abstracted in these proceedings.

GENERAL SESSIONS

Address of Welcome. Chancellor R. B. HOUSE, University of North Carolina.
Presidential Address: Some ecological phases of a prairie region with special reference to insect ecology. O. C. BRADBURY, Wake Forest.
x*Origin of the Carolina Bays: Evidence from some peat profiles.* B. W. WELLS, N. C. State.
Effect of 2,4-D compounds on some aquatic plants. L. A. WHITFORD, N. C. State.
x*Bioelectric potential transients accompanying closing movements of the lobes of Venus' fly-trap.* OTTO STUHLMAN, JR., and E. B. DARDEN, U. N. C.
Notes on type localities for Polycodium *and some cytological findings.* B. E. SMITH Wake Forest.

The effect of chemical control of suckering upon some aspects of quality in flue-cured tobacco. A. B. PACK, N. C. State.

x*Absorption of radioactive phosphorus by mycorrhizal roots of pine.* P. J. KRAMER and K. M. WILBUR, Duke.

x*A report on the excavation of the site of an Indian village on the Yadkin River near Trading Ford.* C. D. HOWELL and D. C. DEARBORN, Catawba.

x*The bee fauna of the eastern United States.* T. B. MITCHELL, N. C. STATE.

x*The distribution of pest chiggers near Duke University.* G. W. WHARTON, Duke.

x*Life cycles of common pest chiggers* (Demonstration). G. W. WHARTON and C. E. FARRELL, Duke.

Investigation of ocean wreck problems; and destruction of immature food fishes. H. F. PRYTHERCH, U. S. Fish and Wildlife Service.

x*The effect of insecticides on the flavor of peaches.* C. F. SMITH, I. D. JONES, J. H. RIGNEY, N. C. State.

BIOCHEMISTRY AND PHYSIOLOGY SECTION

x*A study of the estimation of oxalic acid in foods.* E. T. VISER AND J. C. ANDREWS, U. N. C. School of Medicine.

x*Some further studies on magnesium-potassium antagonism in the animal organism.* SUSAN GOWER SMITH, Duke School of Medicine.

x*Sympatholytic effects of quinine and quinidine.* E. P. HIATT, U. N. C. School of Medicine.

x*Lipide phosphorylation in the liver as related to the dietary supply of methyl donors and methyl acceptors.* CAMILLO ARTOM and W. E. CORNATZER, Bowman Gray.

x*Lipide phosphorylation in the liver of rats fed thiourea and related compounds.* W. E. CORNATZER and CAMILLO ARTOM, Bowman Gray.

Induced tolerance to low barometric pressures. F. G. HALL, Duke School of Medicine.

Action of some inhibitors on the glucose-6 phosphatase of the liver. MARJORIE A. SWANSON, Bowman Gray.

x*Toxicity of radioactive phosphorus in mice on various diets.* W. E. CORNATZER, DAVID CAYER, G. T. HARRELL, JR., and CAMILLO ARTOM, Bowman Gray.

x*The effect of certain organic anions on peptide and amide linkages.* G. C. KYKER and S. L. STEELMAN, U. N. C. School of Medicine.

BOTANY SECTION

The accumulated sediments of Singletary Lake as indicating pleistocene and post-pleistocene change. D. G. FREY, U. N. C.

Amount of sore shin on medium and broad-leaf varieties of flue-cured tobacco. T. E. SMITH and S. J. HASSELL, McNair's Yield Tested Seed Co.

Tobacco leaf curl. F. A. WOLF, Duke.

A new group of organisms related to Actinomyces, J. N. COUCH, U. N. C.

The physiology of a blue stain mold with special reference to production of ethyl acetate. M. A. GORDON, Duke.

x*A fungistatic Actinomycete isolated from soil.* GLEN R. GALE and J. R. WARREN, Duke.

The compositae of Wake, Durham, and Orange counties. R. K. GODFREY, N. C. State.

x*Cytology, morphology, and taxonomy of* Diamorpha. J. E. O'CONNELL, Wake Forest.

A cytotaxonomic study of the North American Sarraceniaceae. C. R. BELL, U. N. C.

North Carolina plant distribution notes. W. B. FOX and R. K. GODFREY, N. C. State.

Preliminary cytotaxonomic study of Crotalaria. EARLENE ATCHISON, U. N. C.

The Sargassa of the West Atlantic. H. L. BLOMQUIST, Duke.

The peanut seedling: II. The morphology of hypocotyl and epicotyl. J. A. YARBROUGH, Meredith.

x*Causes of succession on abandoned fields in the Piedmont of North Carolina.* CATHERINE KEEVER, Duke.

GEOLOGY SECTION

A brief discussion of off-shore bars. S. L. BLANTON, U. N. C.

x*Outlier near Raleigh, North Carolina.* J. M. PARKER, III. N. C. State.

Stream piracy along the Blue Ridge. W. A. WHITE, U. N. C.

x*Talc and soapstone in North Carolina.* J. L. STUCKEY, N. C. State.

Some silica resources of North Carolina. S. D. BROADHURST, Department of Conservation and Development.

x*Ellipticity of Carolina Bays.* W. F. PROUTY, U. N. C.

x*Fossils from Harrellsville, North Carolina.* E. W. BERRY, Duke.

x*The breaking characteristics of argilutites.* R. L. INGRAM, U. N. C.

MATHEMATICS SECTION

x*On the approximation of irrational numbers by the convergents of their continued fractions.* ALFRED BRAUER and NATHANIEL MACON, U. N. C.

x*Multiple periodic functions.* J. M. THOMAS, Duke.

x*A remark on Oppenheim's paper: "Quadratic fields with and without Euclidean Algorithm."* O. H. HOKE, U. N. C.

x*On systems of linear equations.* J. W. LASLEY, JR., U. N. C.

PSYCHOLOGY SECTION

(N. C. Psychological Association)

x*Some relations of movement responses to creativity.* DOROTHY G. PARK, Meredith.

x*Methods of adjusting to success and failure in certain chronic medical disorders.* L. D. COHEN, Duke.

x*Music as a factor in industrial production.* WILLIAM MCGEHEE and J. E. GARDNER, Fieldcrest Mills.

x*Problems in the statistical combination of criterion variables.* DOROTHY C. ADKINS, U. N. C.

Presidential Address: Psychology in North Carolina—1949. WILLIAM MCGEHEE, Fieldcrest Mills.

x*Consistency of production as related to personal and work data of some women textile workers.* H. C. OLSON, N. C. State.

x*Discrimination learning and performance in rats using continuous and intermittent reinforcement.* S. B. LYERLY, U. N. C.

The origin and extinction of emotionally negative avoidance behavior in rats. J. M. BEVAN, DUKE.

x*The use of galvanic skin response in testing pre-published advertising copy.* EDWIN GOLIN, U. N. C.

x*Survey of employee attitudes in a textile mill.* ORA M. JONES, Duke.

WILDLIFE SECTION

Food habits of the opossum in Sumter County, Alabama. R. J. WHEELER, JR. Wildlife Resources Commission.

Waterfowl kill and census data from Currituck Sound during the 1948–49 season. T. S. CRITCHER, Wildlife Resources Commission.

Some observations on the effects of airplane applications of DDT to forest and aquatic insects. H. K. TOWNES, N. C. State.

The technique of making fish models for educational purposes. H. F. PRYTHERCH, U. S. Fish and Wildlife Service.

Comparison of the microflora of a fertilized and unfertilized fishpond. L. A. WHITFORD, N. C. State.

x*Three piedmont reservoirs.* E. E. HUESKE, Wildlife Resources Commission.

The distributions of fishes in the Mississippi drainage system of North Carolina. J. R. BAILEY, Duke.

Age determination in gray squirrel populations. RAY ALLISON, N. C. STATE.

ZOOLOGY SECTION

Studies on the anatomy and course of ciliary currents in the stomach of Ostrea virginica. A. F. CHESTNUT, U. N. C. Institute of Fisheries Research.

x*Speciation in the field cricket,* Gryllulus assimilis *Fab.* B. B. FULTON, N. C. State.

x*Histological observations on the metamorphosis of male* Habrobracon. D. S. GROSCH, N. C. State.

x*The inheritance of ectrodactylism–a preliminary report.* C. D. HOWELL and T. S. BARRINGER, Catawba.

x*Parasitic crustaceans from Bimini.* A. S. PEARSE, Duke.

x*The circulatory system of conjoined twin calves.* W. O. PUCKETT, Davidson.

A midwinter "weather movement" of some small birds. T. L. QUAY, N. C. State.

x*Some comments on the study of Myrmecophiles.* M. W. WING, N. C. State.

x*A preliminary report on the use of chick embryonic extract in the culture of amphibian pigment cells.* H. E. LEHMAN, U. N. C.

Abstracts:

Origin of the Carolina Bays: Evidence from some Peat Profiles. B. W. WELLS.

Examination of the bottom peat in some shallow bays strategically located near the margin of the Talbot terrace in Brunswick County near Southport, N. C., disclosed the uniform presence of waterlily pollen, a certain indicator of open water conditions shortly after the time of bay formation. Had the depression been gradually formed in accordance with the solution theory, the basal peat would have been of the shrub-bog or related woody type, since the sites of these upland bays undergo seasonal fluctuation of the water table. During the dry periods any aquatic forms in the primary very shallow depressions would be eliminated. The woody shrub-bog species however, being adapted to both low and high water tables, would dominate the area.

While this evidence is definitely against the solution theory, it cannot be interpreted as direct positive evidence for any other theory.

Bioelectric Potential Transients Accompanying Closing Movements of the Lobes of Venus' Fly-Trap. OTTO STUHLMAN, JR., and E. B. DARDEN.

The method used for measuring the bioelectric potentials is a modified Wheatstone bridge arrangement designed by Burr, *et al.*, (Yale Jour. of Biol. **9:** 65–76, 1936) for measuring slow changes in mammalian potentials. Contact potentials of the electrodes across which the bioelectrical potentials were placed were minimized by using a pair of Ag-AgCl reversible electrodes in dilute KCl, terminating in a glass capillary containing a small asbestos-fiber wick, which served as the contact electrode on the surface of the plant where the e. m. f. originated.

Closure of the trap-like structure at the end of the spatulated petiole of Venus fly-trap normally follows when any one of the spike-like trigger hairs or the irritable inner epidermis is stimulated. The earlier work of the senior author showed that speed of closure depended on the pattern of excitation, which was hypothecated to originate as a localized destruction of the degree of polarization, which progressively spread as an equipotential electrical wavefront propagated over the surface of the lobe at about 3.0 cm. per sec. (Bull. Torrey Bot. Club **75:** 22–44, 1948).

The present experimental evidence shows that the hypothesis was justified. The excitatory wavefront was found to be a negative potential of about 0.05 volt for summer growth or as low as 0.01 volt for winter growth plants. It is measurable as a diphasic or monophasic potential pulse depending on the position of the nonpolarizable electrodes. The exact shape, speed, and origin of the electrical impulse is being explored with the aid of an oscillograph.

Absorption of Radioactive Phosphorus by Mycorrhizal Roots of Pine. P. J. KRAMER and K. M. WILBUR.

Since the absorption of mineral nutrients by mycorrhizal roots has not been measured directly, a study was made of the absorption of radioactive phosphorus (P^{32}) by mycorrhizal and non-mycorrhizal roots of pine. Root tips and root

segments were freed of foreign material and immersed in a dilute solution of P^{32} in the form of phosphate ion, having an activity of 100 to 500 microcuries per liter. After 3 or 4 hours the roots were removed, rinsed, and dried between glass plates and radioautographs made. Some roots were cut into segments and the amount of P^{32} present in each segment measured by Geiger-Müller counter.

Relatively little phosphorus was accumulated in the older suberized portions of the main roots and relatively high accumulations occurred in the unsuberized regions near the root tips. The coralloid clusters of mycorrhizal roots showed the largest accumulations, supporting the view that they are very active in the absorption of minerals. Relatively great accumulation also occurred even in those short roots which show none of the hypertrophy or dichotomous branching characteristics of typical mycorrhizae. Fungal hyphae appear to accumulate particularly large quantities of phosphorus. In a few instances autographs indicated that completely suberized roots had absorbed considerable phosphorus, but examination under the microscope showed that such roots were covered with a superficial layer of mycelium. Geiger counts of mycelium removed from roots also indicated high accumulation of P^{32}.

Addition of 0.001 M sodium azide, which inhibits respiration, to the solution reduced the accumulation of P^{32} in pine root tips to 42% of the control rate but only reduced accumulation in root segments bearing mycorrhizal branches to 67% of the controls.

It is clear that mycorrhizal roots can absorb much larger quantities of phosphorus than non-mycorrhizal roots. It seems possible that mycorrhizal roots not only have a greater surface, but also a greater capacity per unit of surface to accumulate phosphorus than non-mycorrhizal roots. Possibly phosphorus accumulation is inhibited to a greater extent by azide in non-mycorrhizal roots than it is in mycorrhizal roots.

A Report on the Excavation of the Site of an Indian Village on the Yadkin River Near Trading Ford. C. D. HOWELL and D. C. DEARBORN.

This site was originally on the southwestern bank of the Yadkin River about one mile below Dukesville. It is now covered by the waters of High Rock Lake most of the time, but when the water is low it emerges as an island. The northeastern border of the site has been washed away. Forty-seven hundred square feet of what remains have been excavated. This is but a small part of the total area of the whole village.

Forty-seven fire pits, shell pits, and refuse pits, in addition to uncounted small firebeds, have been discovered. Forty-six post molds have also been found and plotted on the map of the site. No recognized pattern has emerged from their arrangement thus far. One human burial of a mature female was uncovered. There were no cultural materials buried with it.

The Indian artifacts found lay consistently in a layer of blackened sand about eight inches thick and at an average maximum of about eight inches below the present surface. They include the following: 6,982 pot shards, representing possibly 200 pots; 446 arrowheads or points, mostly fragments; thousands of

chert chips; 24 chert drills; 9 bone awls; 18 hammerstones, most of them pitted; 49 rough-chipped chert "hoes"; 18 scrapers; 16 abrading and polishing stones; 3 pestles or fragments of pestles; 2 single-holed pendants; 2 parts of pottery pipes; 3 antler tools; many bones of mammals, birds, fish, and turtles; and parts of one human skeleton, including a fairly complete skull and right femur.

No articles of European origin have been found. Therefore, the village is tentatively considered to antedate the period of contact with European traders and to be older than Saponi Village mentioned by Lawson as being at Trading Ford in 1701.

The Bee Fauna of the Eastern United States. T. B. MITCHELL.

A synopsis of the bees of the eastern United States is in course of preparation. Approximately 750 species, in each sex, have been keyed out, about 180 of these apparently being new to science. This large number of undescribed forms is indicative of the incomplete state of our knowledge of these insects. Revisional work is needed badly in several of the groups, and a more complete knowledge of their habits and ecological relationships with the flowering plants, including the crop plants.

Bees exhibit a wide range of variation in size, structure, color and habits. Most of them are solitary, nesting in the soil or in a variety of sites above the ground surface. Flight periods tend to be long in the more generalized species, which visit a considerable range of flowers, but are short in the more specialized oligolectic forms which visit only one or a very limited number of plants. The period of greatest activity is from mid-morning to mid-afternoon. Bees are among the most essential of the beneficial types of insects, because of their importance in the pollination of the numerous important plants. The honey bee is the most valuable single species, but the role of the wild bees in general is an important one, and studies are needed to determine which are of more importance and to discover means for their conservation.

The Distribution of Pest Chiggers Near Duke University. G. W. WHARTON.

The distribution of pest chiggers near Duke University has been studied from several aspects during the last year and a half with the support of a grant-in-aid from the Division of Research Grants and Fellowships of the National Institute of Health, U. S. Public Health Service. Daily collections have been made and correlations with temperature and rainfall have been attempted. The last chigger of the 1947 series was collected on October 20. The first specimen of 1948 was collected on May 17. During 1947 the greatest number of specimens was collected during the last week in July and the first week in August. Larvae were uncommon when subsurface temperatures dropped below 60°F. Not enough data have been accumulated in this study to detect the seasonal effects of rainfall on the numbers of chiggers collected. The diurnal distribution of chiggers was investigated by making hourly observations continuously for 62 hours. Chiggers were collected most abundantly during daylight hours but the temperature records indicate that the chiggers were most readily collected between temperatures ranging from 75 to 85°F, and that time of day is not of itself the controlling

factor. During part of the time of the hourly observations rain fell. When the ground was covered with droplets of water few chiggers were collected. The distribution of chiggers in respect to soil and type of cover was also investigated. Chiggers were collected more frequently in loam than in either clay or sand. They were most common in brambles and practically non-existent under hardwood stands.

Life Cycles of Common Pest Chiggers. G. W. WHARTON and C. E. FARRELL.

In the course of work on a U. S. Public Health Research Grant, colonies of pest chiggers have been maintained for the past two years. There are eight stages in the life cycle as follows: egg, deutovum, larva, nymphochrysalis, nymph, imagochrysalis, males and females. Preserved and living specimens of these stages were shown.

The Effect of Insecticides on the Flavor of Peaches. C. F. SMITH, I. D. JONES, and J. A. RIGNEY.

Peach trees were sprayed with benzene hexachloride (10 per cent gamma isomer), chlordane, chlorinated camphene, parathion, or lead arsenate at different times during the growing season. Samples from the various plots were picked when the peaches were ripe, analyzed for spray residue and taste-tested for off-flavor. In the flavor tests the peaches receiving only lead arsenate were used as a standard. Flavor tests were conducted on fresh and canned fruit.

Analyses of residue on the fruit at harvest were made for benzene hexachloride, parathion, and chlorinated camphene.

In the flavor tests, benzene hexachloride affected the flavor of fresh fruit. The flavor of the canned fruit was similarly affected by the benzene hexachloride except where it was used only in the petal fall and shuck-off sprays. The off-flavor became more noticeable as the number of sprays were increased or as they were applied nearer harvest.

Parathion and chlordane gave somewhat erratic performance in the flavor tests. Twice parathion was significantly better than anything else in the test, while in one test it was poorer than lead. Chlordane was by far the best in two tests. In another test it was even significantly worse than 4 applications of benzene hexachloride. However, when results of all the tests were pooled there was no significant difference between lead arsenate, chlordane, or parathion.

Studies on the Determination of the Oxalic Acid Content of Some Common Foods. E. T. VISER and J. C. ANDREWS.

Since there seemed to be a higher incidence of kidney and bladder stone formation in eastern North Carolina than would be considered normal, it has been suspected that this section may be included in a "stone district", a geographical area which for one reason or another exhibits this higher than normal incidence of stone disturbances among its populace. In an effort to find out if the common foods grown in the area might be responsible, a study was begun of the oxalic acid content of 43 foods. Briefly, the method included the following

procedures: the food was thoroughly dried and defatted with CCl_4 (if the fat content was above 2–4%). The dried material was ground until it would pass through a 16-mesh screen. A representative portion was taken and kept in a desiccator until samples were needed for analysis. Two- to four-gram samples of the food material were placed in sintered glass extraction thimbles and extracted with HCl in Soxhlet extractors. The resulting acid extracts were filtered, made to volume, and aliquots extracted with ether in modified Clausen extractors. Water was added to the resulting ether extracts, the ether distilled off and the oxalic acid remaining in the aqueous solutions precipitated with saturated $CaCl_2$ solution. After the precipitates were centrifuged and the supernatant portions discarded, the CaC_2O_4 was dissolved in normal H_2SO_4, heated and titrated with standard $KMnO_4$. Using samples of foods to which known amounts of oxalic acid were added we have established the optimal conditions for this determination with respect to the various steps in the method.

Some Further Studies on Magnesium-Potassium Antagonism in the Animal Organism. SUSAN GOWER SMITH.

A paralysis produced in the laboratory on a diet low in potassium and lacking several B complex factors has some characteristics in common with the paralysis produced by intravenous injection of magnesium. Both are flaccid, affecting the extremities and both have a definite inhibitory effect on respiration. The respiratory rate decreases to a marked degree. Death, when it occurs, is due to respiratory failure in both instances. Though etiologically different they appear to operate through a common neuro-mechanism.

It has been reported (Arch. Biochem. **20**: 473, 1949) that the i. v. administration of $MgSO_4$ results in a consistent decrease in the serum potassium level. Preliminary experiments in which four dogs were given potassium chloride at different concentrations coincidently with the magnesium sulfate would seem to indicate that the respiratory symptoms correlate rather closely with the serum potassium level. Where the potassium chloride injected was sufficient to maintain normal or higher than normal serum potassium values, the respiratory inhibition was wiped out. The respiratory rate was actually increased when the serum potassium was forced to a level higher than normal.

Sympatholytic Effects of Quinine and Quinidine. E. P. HIATT.

The antagonistic effect of oral and intravenous doses of quinine and quinidine on the circulatory action of intravenously injected epinephrine has been studied in anesthetized and unanesthetized dogs. It was found that plasma concentrations of 5 to 10 mgm. per liter of these alkaloids will block the pressor effect and changes in rate which follow injection of test doses of epinephrine (0.5 cc. of 1:10,000).

It was further demonstrated that similar concentrations will block the pressor effect of stimulation of the splanchnic nerves of anesthetized dogs.

These findings correlate with our previous demonstration that the cinchona alkaloids will cause renal vasodilation and lower the blood pressure of dogs with experimental neurogenic hypertension. Evidence exists to indicate that these agents can block all types of motor nerve endings.

Lipide Phosphorylation in the Liver as Related to the Dietary Supply of Methyl Donors and Methyl Acceptors. CAMILLO ARTOM and W. E. CORNATZER.

The hypothesis that the dietary supply of transferable methyl groups represents a limiting factor for the synthesis of phospholipides in the liver would offer a rather simple explanation of the lipotrophic action of choline or choline precursors. The findings of an increased turnover of liver phospholipides (especially of the lecithins) following the administration of choline is in line with this hypothesis. Since, however, similar effects have been observed after ethanolamine was given, it has been postulated also that a relative deficiency of both methyl donors and methyl acceptors for the synthesis of choline might occur in animals on very low protein diets.

This possibility has now been investigated by comparing the isotopic concentrations in the liver lipides of rats maintained on various diets and killed six hours after administration of Na_2HPO_4 containing radioactive P.

The average specific activity of the lipide P in rats on a stock diet was lower than in rats on a 5 per cent casein, high fat diet, which caused an extensive fatty infiltration of the liver. When this diet was supplemented with ethanolamine, or with methionine, or with both, somewhat higher values were usually found. Much more marked increases in these values were observed following the isolated or combined administration of a single large dose of these substances. These increases were approximately of the same magnitude in the groups on the unsupplemented diets as well as in those on diets supplemented with the methyl donor, or the methyl acceptor only, or the mixture of the two. Considerable decreases in the specific activity of the total phospholipides (more especially of the choline-containing portion) were observed only in experiments in which the diets were supplemented with quanidoacetic acid or with diethanolamine.

From the present results as well as from other data of the literature, no simple correlation is apparent between the rate of lipide phosphorylation in the liver and the amounts of lipotropic factors in the diet. Even with diets which contain little protein and no preformed choline, choline and ethanolamine seem to be available to the animal in amounts adequate for the synthesis of phospholipides in the liver at a rate much above the "normal" level. A deficiency of the nitrogenous precursors for the formation of phospholipides in the liver becomes apparent only after the addition to the diets of substances which either compete for the methyl groups (e. g. quanidoacetic acid) or act presumably as metabolic antagonists of the methyl acceptor in the synthesis of choline (e. g. diethanolamine).

(This work was supported by the U. S. Atomic Energy Commission under Contract No. N8onr-63701 between the Bowman Gray School of Medicine and the Office of Naval Research, U. S. Navy Department. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

Lipide Phosphorylation in the Liver of Rats Fed Thiourea and Related Compounds. W. E. CORNATZER and CAMILLO ARTOM.

Several groups of male albino rats of about 80 g. body weight were given various antithyroid drugs (thiourea, thiouracil and N-propylthiouracil) for periods varying between 15 and 35 days. The rats were maintained on diets with an adequate protein content, but during the last week of the experiment, they were transferred to a low protein, low fat diet (Diet 26 containing casein 5 parts, Crisco 4, cod liver oil 1, dextrin 42, sucrose 42, roughage, salts and B-vitamins). As a rule, the drugs were added to the diets, but in many of the experiments additional amounts were given parenterally or by stomach tube. Control groups were run simultaneously and fed the same diets, but did not receive the substances tested. At the end of the experiments all animals were injected intraperitoneally with a solution of Na_2HPO_4 containing P^{32}, and, after six hours, they were killed by decapitation. The lipides extracted from the liver were weighed and their radioactivity and phosphorus content determined. In the first series of experiments, the radioactivity of the lipides extracted from some of the rats receiving the drugs were extremely low. However, efforts to reproduce these occasional findings with greater frequency and consistency were not successful. Even if these exceptionally low results are disregarded, the average specific activity of the lipide P in the liver of the rats receiving the substances was significantly lower than in the controls.

In a second series of experiments, the isotope and phosphorus determinations were made not only in the lipide extracts, but also in the inorganic fraction. Thus, it became possible to express the specific activity of the lipide P as a function of the specific activity of the inorganic P ("relative specific activity"). When the relative specificity values were compared, the difference between the averages in the treated and untreated rats became even more marked and more significant. A decrease of the same order of magnitude was noted also in the specific activity of the lipides from a few rats which received thioacetamide, a compound which recently has been claimed to cause cirrhotic lesions in rat liver.

In a third series of experiments the food intake of the control rats was restricted to approximately the same amounts as that of rats receiving thiourea. The average specific activities of the lipide P in the liver of both treated and untreated animals were approximately the same. When, however, the values were expressed as "relative specific activity," a significant decrease in the animals receiving the drug is again apparent. On the contrary, in seven rats in which a total thyroidectomy was performed, there was no significant change from the controls either in the specific activity or in the relative specific activity of the lipide P. It seems likely that the decreased formation of phospholipides in the liver of animals receiving thiourea and related substances is chiefly due to a direct pharmacological action of the drugs administered.

(This work was supported by the U. S. Atomic Energy Commission under Contract No. N8onr-63701 between the Bowman Gray School of Medicine and the Office of Naval Research, U. S. Navy Department. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

Toxicity of Radioactive Phosphorus in Mice on Various Diets. W. E. CORNATZER, DAVID CAYER, G. T. HARRELL, JR., and CAMILLO ARTOM.

The present investigation is a part of a more extended study undertaken with the idea that the resistance of the organism to the toxic effects of radioactive isotopes introduced into the body may be decreased by alterations in the functional capacity of the liver. This point would, of course, be of practical interest for the use of radioactive isotopes as diagnostic and therapeutic agents in patients with liver diseases since in these individuals even small doses of radioactivity could exert an additive harmful action.

To our knowledge, the only data on the toxicity of P^{32} are those of Anthony and Snyder (Atomic Energy Commission, Document MDDC-881). On the basis of a few experiments on mice (presumably maintained on a stock diet), these authors suggest that the LD_{50} after one injection of P^{32} is around 4 microcuries per gram of body weight. With this dose 4 out of 6 mice died between 16 to 21 days.

In the present experiments we have studied the mortality and survival time of mice maintained on diets of known composition and injected with radioactive phosphorus as sodium diphosphate. We have investigated the possible role of a deficiency of lipotropic factors in the diet, such a deficiency leading to a fatty infiltration of the liver. If in this condition the toxicity of the isotope were increased, supplementation of the diet with choline should give a more or less marked protection.

Several groups of mice (approximately 20 gm. body weight) were transferred from a stock diet to a low protein, high fat diet (Diet 31, containing casein 10 parts, Crisco 30, cod liver oil 2, sucrose 29, dextrin 23, roughage, salts and B vitamins). The animals were maintained for five days on the diets, then they were injected with a single dose of radioactive phosphorus and kept under observation for three weeks. To date, a total of 120 mice have been used.

There were no deaths among mice not injected with radioactive P and maintained for 25 days on the unsupplemented diet. Of the animals injected with 2 microcuries per gram of body weight and maintained on either the unsupplemented or supplemented diet none died in 21 days. With 4 microcuries per gram of body weight the mortality at the twenty-first day was 16% and the average survival time was of 20 days for both the controls on the unsupplemented diet and the mice of the choline supplemented diet. With 6 microcuries per gram of body weight the mortality has been 72% and 86% and the survival time 16 and 12 days respectively. With 8 microcuries per gram of body weight the mortality was 89% and 89% and the average survival time 12 and 13 days respectively.

In another group of rats injected with 6 microcuries per gram of body weight the level of the fat in the diet was decreased from 32 to 5 per cent (Diet 34). There was a slight decrease in mortality but no change in the survival time after injecting 6 microcuries per gram. Likewise, no significant protection was observed when the protein content of the low fat, low protein diet was increased from 10 to 26% (Diet 29).

(This work was supported by the U. S. Atomic Energy Commission under a

contract with the Bowman Gray School of Medicine. The P^{32} used was supplied by the National Laboratory, Oak Ridge, Tennessee, on allocation from the U. S. Atomic Energy Commission).

The Effect of Certain Organic Anions on Amide and Peptide Linkages. G. C. KYKER and SANFORD L. STEELMAN.

The rates of hydrolysis at 65°C. of the amide and peptide linkages of certain proteins (egg albumin, serum albumin, gelatin and hemoglobin) by hydrochloric acid in the presence of certain organic anions depend on the concentration of the protein, the anion, and the hydrochloric acid and on the nature of the protein. Most important of all is the ratio of the concentration of the protein to the concentration of the anions. The differences in the hydrolytic effectiveness of the organic anions do not parallel, in all cases, the differences in the affinities of the anions of the acids for proteins as suggested by Steinhardt (J. Research NBS **29**: 315, 1942). A maximum rate of amide hydrolysis is reached with sodium dodecyl sulfonate and egg albumin. This is not the case with the other proteins studied. Sulfosalicylic acid, which has an "intermediate" anion affinity for wool protein, inhibits amide hydrolysis of egg albumin.

The catalytic effect of organic anions on the peptide hydrolysis is limited to the initial stages of hydrolysis and when the protein is further split, the rate tends to approach that of HCl. For the ones studied, when the protein was approximately 25% hydrolyzed the rate began to approach closely that of the HCl.

The mechanism for the catalytic effect is uncertain but may be due to the denaturating action of the anion on the protein and to the combination with it. As the hydrolysis proceeds, there is evidently less tendency of the anion to combine and the rate of hydrolysis approaches that of HCl.

The Physiology of a Blue Stain Mold with Special Reference to Production of Ethyl Acetate. MORRIS A. GORDON.

An ascomycete, *Endoconidiophora moniliformis* (Hedge.) Davidson, which causes blue stain of pine wood, produces, when grown in pure culture, an odor similar to that of banana oil. This odor is found to result from the presence of ethyl acetate, which is formed when the fungus is cultured on any of several chemically known media. Thiamin must be supplied for the growth of *E. moniliformis* on these media, in which the production of esters parallels gain in dry weight of the fungus. Among the initial materials (carbon sources) from which ethyl acetate is derived are dextrose and ethyl alcohol. Asparagin, urea, and several other organic nitrogen compounds serve as good nitrogen sources for both growth and ester production. A discussion of the possible phase-sequence involved in the production of ethyl acetate is presented.

A Fungistatic Actinomycete Isolated from Soil. G. R. GALE and J. R. WARREN.

In a study of the effects of DDT on the microflora of soils, tomato plants were sprayed with a solution of 200 parts per million DDT. From the soil in which

these plants grew a fungistatic actinomycete has been consistently isolated. In Petri dish cultures this organism has strongly inhibited a wide variety of fungi. That the inhibitory substance is an extracellular diffusible compound is indicated by the occurrence of fungistasis at distances of approximately two centimeters from the actinomycete colony.

Among the inhibited organisms are the following: *Mucor genevensis* Lendner, *Rhizoctonia solani* Kuhn, *Sclerotinia cinerea* (Bon.) Wor., *Sclerotium rolfsii* Sacc., *Alternaria tenuis* Nees, *Helminthosporium sativum* Pam., *Venturia inaequalis* (Oke.) Aderh., *Epidermophyton interdigitale* (Priestley) MacCarthy, *Blastomyces dermatitidis* Cast., *Trichophyton mentagrophytes* Gedoelst.

Cytology, Morphology, and Taxonomy of Diamorpha cymosa. J. E. O'CONNELL.

Two species of *Diamorpha* have been reported from North Carolina; however, this paper recognizes only one of them as a good species. This conclusion is based on the general characteristics of the plants in conjunction with previous observations.

Diamorpha cymosa appears sporadically in Georgia, Tennessee, South Carolina, and North Carolina. It is an herb which belongs to the order Rosales and to the family Crassulaceae.

Each of the four ovaries, which make up the compound ovary, begins its development independently from a single cell in the base of the flower. After many mitotic divisions, the ovaries become fused for about one-half of their length.

The growth of each stamen begins from a superficial cell in the base of the flower. This cell actively divides to produce a mass of sporogenous tissue which is pushed up from the base of the flower by the stalk of the anther.

The microsporangia develop in the usual manner. Spore mother cells pass through meiotic divisions to produce the tetrad. The spores are released and develop to maturity.

The ovule shows a nucellus and two integuments. The integuments are two cells in thickness. The megaspore mother cell is produced from a subepidermal cell. It produces four megaspores, only one of which develops to form the embryo sac. The mature embryo sac is very small (25 microns and less) and it must be observed under oil. It contains one large egg, two oval-shaped synergids, three small antipodals, and two small polar nuclei.

Diamorpha cymosa has a chromosome number of $2n = 18$.

Causes of Succession on Abandoned Fields in the Piedmont of North Carolina. CATHERINE KEEVER.

Causes of succession were sought in the life cycles of, and effects of environmental factors on, the three major dominants: horseweed (*Leptilon canadense* L.), aster (*Aster ericoides* (L.) Britton), and broomsedge (*Andropogon virginicus* L.), which were studied in the field and greenhouse. Horseweed is the dominant of first year fields because the seeds mature and are ready to germinate at the time most farm land is being cultivated the last time for the season. Horseweed

loses its dominance the second year because the seedlings are stunted by decaying horseweed roots, and because of the competition among the numerous horseweed plants and young asters. Aster is delayed in assuming dominance until the second year because it germinates about six months later than horseweed and is retarded in growth by the shade and competition of the established horseweed, and by the effects of decaying horseweed roots. Aster loses its dominance at the end of the second year because the first generation fails in competition with the more drought-resistant broomsedge that is becoming established at that time, and because the seedlings are not able to grow to maturity in the shade of the increased vegetation. Broomsedge is delayed in assuming dominance until the third year because there is not a sufficient source of seeds until that time. A species may become dominant, not because a previous invader makes the environment more favorable for it, but in spite of the effects of the original invader.

Outlier near Raleigh, North Carolina. J. M. PARKER, III.

An outlier of Coastal Plain sediments occurs on the Johnston-Wake county line near U. S. Highway 70 about ten miles southeast of Raleigh, N. C. It rests on granite and is overlain by "high-level" (? Pleistocene) gravel and sand. The lower portion consists of consolidated ferruginous sandstone; higher beds are a completely silicified coquina containing fragmentary molluscs, coral, and palm wood. Eocene age is suggested.

Talc and Soapstone in North Carolina. J. L. STUCKEY.

Talc and soapstone deposits are widely scattered throughout the Appalachian mountains and Piedmont plateau of North Carolina and occur in three geological settings. These settings are: (1) in peridotites, dunites, and pyroxenites; (2) in hornblende gneisses and schists; and (3) in dolomitic limestones and marbles. In the deposits associated with (1) and (2) soapstone predominates, while in those associated with (3) talc predominates. All the deposits are genetically similar in that they have been formed by hydrothermal solutions of igneous origin.

Ellipticity of Carolina Bays. W. F. PROUTY.

The ellipticity of 130 bays from four counties in North and South Carolina was measured. These bays varied in length from 500′ to 6000′. The maximum ellipticity was 0.457; the minimum was 0.270 and the average was 0.363.

There is a variation in the ellipticity of bays of all sizes but a larger variation in the bays of smaller size. In every locality where measurements were made the larger bays have an average ellipticity greater than that of the smaller bays. The meteoritic theory of bay origin offers an explanation for the above observed facts.

In passing through the atmosphere the heat of friction causes some meteorities to break open or suffer mild explosion. Due to this the fragments travel slightly different paths which give different orientations to the bays formed by the different pieces which were thrown to the right or the left. The pieces thrown more

upward would form bays with greater ellipticity, and those thrown more downward would form bays with less ellipticity. As a rule, the smaller fragments would be thrown into a travel course more at variance with that of the parent meteorite than would larger fragments. Unless the bursting of the parent meteorite occurred close to the Earth the greater slowing down of the smaller meteorites than of the larger would, in many instances, allow the larger fragments travelling less curved paths to form bays with even greater ellipticity than that of the smaller meteorites which were thrown more upward and forward by the mild atmospheric explosion of the parent meteorite.

Fossils from Harrellsville, North Carolina. E. W. BERRY.

Vermetus graniferus Say, *Turritella plebeia* Say, *T. cf. variabilis* Conrad, *Cepidula fornicata* (L.), *Corbula inaequalis* Say, *C. cuneata* Say, *Spisula subponderosa* (d'Orb.), *Ensis directus* (Conrad), *Venus mercenaria* L., *Venericardia granulata* Say, *Astarte calvertensis* Olen, *Plicatula densata* Conrad, *Pecten jeffersonius* var. *septenarius* Say, *Ostrea percrassa* Conrad, *Glycymeris subovata* (Say), *Arca subrostrata* Conrad, *Leda liciata* (Conrad), *Nucula prunicola* Dall, and *Septastrea marylandica* (Conrad) have been tentatively identified from an outcrop on the east side of the road going from Harrellsville to Wiccoon River just before you reach the ferry. These can all be referred to the upper Miocene or Yorktown Epoch. There is about 10 feet of Yorktown at the localitv with about 5 feet of Pliocene-Pleistocene sands on top.

The Breaking Characteristics of Argilutites. R. L. INGRAM.

Clay sediments break into fragments that can be described as massive, flaky, flaggy, or some combination of these. The parameters that control the breaking characteristics are numerous and not completely known.

Analyses show that grain size, carbonate content, and kinds and proportions of clay minerals cannot explain the differences in breaking characteristics in a random collection of argilutites. The massive varieties are characterized by a random arrangement of the clay particles, a very low organic content, and the presence of primary colloidal sesquioxide or silica particles which interfere with the parallel orientation of the clay particles. The non-massive varieties are characterized by a sub-parallel or parallel arrangement of the clay particles, a higher organic content, and the absence of primary colloidal sesquioxide particles. Flaky and flaggy forms differ only in that the flaggy ones contain more tempering cement.

On the Approximation of Irrational Numbers by the Convergents of Their Continued Fractions. ALFRED BRAUER and NATHANIEL MACON.

Let ζ be any positive irrational number, and let A_n and B_n denote the numerators and denominators of the convergents in the expansion of ζ as a regular continued fraction. We set

$$\left|\zeta - \frac{A_n}{B_n}\right| = \frac{1}{\lambda_n B_n^2}$$

In 1891 Hurwitz obtained the important theorem that there exist infinitely many λ_n which are greater than $\sqrt{5}$ for every ζ. It was proved by Vahlen in 1895 that of each pair of consecutive λ_n at least one exceeds 2, and by Borel in 1903 that at least one of three consecutive λ_n is greater than $\sqrt{5}$.

It is shown in this paper that of each five consecutive λ_n, either at least two exceed $\sqrt{5}$, or at least one of them exceeds 3. Similar results are obtained for any set of $3m + 2$ consecutive λ_n ($m = 2, 3, \ldots$). Moreover, estimates for sums and products of consecutive λ_n are obtained. In particular, it is shown that

$$\liminf \frac{1}{m}\left(\sum_{i=0}^{m-1} \lambda_i\right) > 2.0169$$

Multiple Periodic Functions. J. M. THOMAS.

It is known that a non-constant analytic function can have one or two but not three independent periods and that the ratio of two independent periods is necessarily imaginary. The present paper bases a proof of these results on geometrical considerations.

A Remark on Oppenheim's Paper: "Quadratic Fields with and without Euclidean Algorithm." O. H. HOKE.

A. Oppenheim (Mathematische Annalen **109:** 349–352, 1934) proved that the real quadratic fields $P(m)$, were $m = 2, 3, 5, 6, 7, 13, 17, 21, 29$, are Euclidean fields. Some other real quadratic Euclidean fields are known, but the problem of finding all such fields is not solved completely.

Oppenheim's proof is also given in Hardy and Wright's *An Introduction to the Theory of Numbers*, second edition (1945), pp. 213–215.

In this paper it will be shown that Oppenheim's proof can be simplified somewhat.

On Systems of Linear Equations. J. W. LASLEY, JR.

It is customary in developing the theory of linear equations first to establish Cramer's Rule and then the theorems of non-homogeneous linear equations. The theory of homogeneous linear equations is regarded, from this approach, as a special case in which the constant terms are all zeros.

The present paper approaches the problem in the reverse manner by developing the theory of homogeneous linear equations first, and obtaining the theory of non-homogeneous linear equations as a special case.

The product structure of the homogeneous linear function together with three fundamental theorems of determinants provide the basis of the development. The existence of a non-trivial solution of the system of homogeneous linear equations is proved at the outset for the case in which the number of unknowns in the system differs from its rank by unity. The proofs of the uniqueness of this solution (except for a proportionality factor) then follows. An alternative form of this solution is obtained and identified with the solution shown earlier. Cramer's Rule next is pointed out as a special case.

For the case in which the rank of the system has any admissible value, a canoni-

cal form for the system is secured involving a replacement principle of columns of certain matrices. The coefficients in this canonical form have properties similar to Kronecker deltas. Questions of existence, uniqueness, and the form of the general solution are considered. A generalization of Cramer's Rule is obtained.

Some Relations of Movement Responses to Creativity. DOROTHY G. PARK.

Problem: To investigate the relation of responses on the Levy Movement Blot test to creativity in college students and thus check on Rorschach's claim that creativity is a correlate of the movement response.

Population: Forty female juniors and seniors in college, twenty judged by students and teachers to be creative, twenty judged as average or non-creative; a second group of 50 college students, including the above plus ten more, five of which were creatives of superior intelligence for whom appropriate non-creative matches could not be found.

Procedure: After the two groups were equated for age, education, sex, and intelligence level, the Levy Movement Blots were administered to each subject individually and the resulting data compared, on the basis of psychometric scoring of movement responses, also of phantasies about each response.

Results: Scores of the 40 protocols of the first group of creatives and non-creatives on the Levy Movement Scale and on the Zubin-Rust Compliance Scale yielded slightly negative relationships between movement responses and creativity. This confirms the finding of Rust in his experiments with the Levy test. However, this agreement with Rust's data does not extend to all the movement scales, as the creatives show up better on the Energy of Movement, Interaction, and Conflict scales, the difference on the Conflict scale being 25%. The highly significant difference of 136% in favor of the creatives appears in the Abstract-Concrete Scale. The Sex Reference Scale shows 69½% difference in favor of the non-creatives. The Park Phantasy Scales show higher scores on Organization made by the non-creatives, but higher scores on Originality and Sensitivity by the creatives.

Scores of the second group, with the over-weight of intelligence in the creatives, yielded similar results in the first three scales. Differences on other scales, particularly a difference of 263.63% higher score for the creatives on the Abstract-Concrete Scale and differences of 10–15% on each of the Phantasy Scales point to the conclusion that intelligence is an important factor in the relationship between movement responses and creativity.

The author disagrees with Rust's interpretation of negative relationships found on the Zubin-Rust scales as proving that "the production of movement responses on the Levy Movement Blots does not have the same relationship to creativity as is claimed for the M response by Rorschach."

Methods of Adjusting to Success and Failure in Certain Chronic Medical Disorders. L. D. COHEN.

Problem: Are there characteristic and different methods of adjusting to success and failure among groups of patients suffering from different chronic medical disorders?

Population: A group of 26 subjects diagnosed with hypertensive cardiovascular disease, a group of 21 subjects with asthma, a group of 25 college students with no history of chronic medical disorders or psychoneuroses or psychoses.

Procedure: All subjects participated in a level of aspiration task involving the Rotter aspiration board. Methods of reacting to success and failure were noted by a number of measures derived from the differences between aspiration bid and actual performance. These measures included: (1) number of shifts (number of changes in aspiration bid), (2) number of shifts appropriate to the previous performance (raising bid after success, lowering bid after failure), (3) number of shifts opposite to the previous performance (lowering bid after success, raising bid after failure), (4) number of failures to shift after success and failure, (5) number of failures to state new bid until reminded by examiner. On the basis of these measures four major methods of adjustment to success and failure were denoted and a rating scale developed: (1) rigid, (2) arbitrary, (3) flexible, (4) conforming. The reliability of the ratings on methods of adjusting to success and failure gave a corrected contingency coefficient of .920 significant at the 1% level of confidence. A validation study utilizing a group of 50 patients from the subjects listed above on whom Rorschach studies had been conducted yielded a corrected contingency coefficient of .658 significant at the 1% level of confidence between ratings based on the level of aspiration and the Rorschach performance.

Results: The hypertensive group used the arbitrary and conforming types of adjustment in preference to any other while the asthmatic group predominantly used the rigid type of adjustment. The types of adjustment were not exclusive for either group but the trends seemed strongly suggestive for each group. The control group showed a preference for the flexible and conforming types of adjustment.

Conclusions: From an analysis of the behavior following success and failure in a level of aspiration task, certain characteristic methods of adjustment become apparent. These methods of adjustment when denoted seem consistent for the subject as determined through the use of another task having entirely different properties (Rorschach). The types of adjustment to success and failure utilized by groups of patients suffering from different chronic medical disorders is suggestively characteristic for each disease and different for different chronic medical disorders.

Music as a Factor in Industrial Production. WILLIAM MCGEHEE AND J. E. GARDNER.

An investigation was made of the effect of music upon 142 female industrial employees performing a highly complex job known as rug setting. The investigation determined the effects of music on production, absenteeism, and employee attitudes.

Music was found to have no significant effect on production. This conclusion was based on (1) a comparison of production on music days with production on no-music days during an experimental five-week period, and (2) a comparison of production during a five-week period prior to the installation of music with production during a five-week period subsequent to the experimental period.

Music appeared to have a salutary effect on absenteeism. A significant drop in absenteeism occurred in the department with the introduction of music. No significant change occurred in another department of equivalent size or in the mill as a whole.

A survey of employee attitudes, conducted by means of interviews and a questionnaire, indicates that music reduced fatigue and increased job satisfaction. A similar survey conducted among supervisors revealed that the supervisors thought the music had improved interpersonal relations, had made their own job tasks easier to perform, and had increased their job satisfaction.

Problems in the Statistical Combination of Criterion Variables. DOROTHY C. ADKINS.

When the relations between each of a set of variables with a single criterion are known, the weights at which the predictor variables should be combined to predict best the criterion can be determined by the multiple correlation approach. Not infrequently in psychological research, however, the ultimate variable in which interest centers is not capable of being measured directly, but several proximate criteria are available. When the relations between each of a set of predictor variables and each of these proximate criteria are known, the problem arises of how best to weight not only the predictor variables but also the criterion variables.

It is noted that, when the number of criterion variables is large, how they are weighted is of little significance. Two situations are distinguished for a small number of criterion variables: (1) that in which all of the criterion variables are assumed to be measures of the same factor; (2) that in which the various criteria are more reasonably to be regarded as different components or relatively independent aspects of an over-all activity in which it is desired to appraise success. In either case, there is the problem of how to combine into a single index the several criterion measures, each weighted on the basis of its respective importance. Characteristics of several solutions that have been proposed are briefly described, but the point of view is taken that no one of them obviates the need for value judgments within the subject-matter area of the investigation in question. Application of factorial analysis to the criterion variables, perhaps together with the predictor variables, may provide a promising approach.

Consistency of Production as Related to Personal and Work Data of Some Women Textile Workers. H. C. OLSON.

Problem: To measure the relationship of consistency of production of spinning-frame operators to the personal variables of age, education, marital status, and number of dependents, and the work variables of seniority, experience, place of residence, merit rating, absences, average hourly production, and total production.

Subjects: The sample is made up of 56 women ring-spinning-frame operators employed in a cotton sheeting mill. It included all spinners within the department who met the imposed criteria of having had a minimum of one year's ex-

perience immediately preceding the experimental period, and of having been absent from work less than one half of the experimental period.

Method: Data for the study were obtained from personnel record forms and from payroll accounts of the spinners. Records of standard time production were collected for the eight-week period from September 8 to November 2, 1947, and, by computing the average deviation, a value of variability in production was derived for these eight periods. This measure of variability (called the Consistency Index) was compared with the variables listed previously by employing chi-square and product-moment correlation techniques. Data pertaining to absence were portrayed graphically by dividing the sample into three equal units on the basis of the Consistency Index.

Results: Consistency Index values show a wide distribution and, when plotted, result in a positively skew curve. Chi-square values and coefficients of correlation revealed no direct relationships that were significant at the 5% level of probability. Some trends are suggested, however, by relatively high chi-square values between the Consistency Index and the variables of experience, per cent of voluntary absences, and per cent of asked-off absences. The highest correlations obtained were those for experience (−.21), voluntary absences (.16), and asked-off absences (−.20). In general, spinners who were the most consistent in their week-to-week production tended to have greater seniority, more experience, less education, a lower percentage of voluntary absences, a higher percentage of asked-off absences, fewer periods of sickness, and more hours on the spinning job during the period studied.

Conclusion: Chi-square and correlation methods disclosed no relationships that were significant at the 5% level. The per cent of categories of absences (voluntary, asked-off, or sick) suggest the best trends. These results are interpreted as showing the more consistent spinners as having either a greater sense of responsibility toward their employer or more pleasant working relationships with their foremen, and these being reflected in the spinners' absence records. The trend with respect to experience is interpreted as a stabilization of work habits and a fitting of work speed to the pace of the spinning machinery.

Discrimination Learning and Performance in Rats Using Continuous and Intermittent Reinforcement. S. B. LYERLY.

Hungry white rats were trained to go to the lighted side in a T-maze. Food reward for a correct response was given on every trial when the light was on the right, and on 50% of the trials when the light was on the left. There were eight trials per day; and the right-left sequences as well as the rewarded and non-rewarded left trials were randomly ordered. A self-correction procedure was used in the training.

All of the animals learned the problem, although most of them developed early position preferences for the right. After the animals had learned the discrimination, daily practice was continued until each animal had run a minimum of 7 consecutive days (or 56 consecutive trials) without error.

During the last several days of the post-learning performance period, several

important differences in the rats' behavior were noted, the most striking of which was the significantly greater running speed when the light was on the right (which was accompanied by reward on every such trial) than when the light was on the left (which was accompanied by reward on only half the trials). Examination of individual trial results discloses the fact that although the simple discrimination problem had been fully mastered and the time curves had apparently reached asymptotic limits, the running behavior was by no means static or fixed, but was varied in a systematic manner depending upon the results of the immediately preceding trial. It is suggested that a tentative explanation of the findings, pending further experimental attack, can best be made in terms of the "expectancy" point of view of Tolman.

(The assistance of Mr. Frank Giraffe in carrying out of this experiment is gratefully acknowledged.)

The Use of Galvanic Skin Response in Testing Pre-Published Advertising Copy. EDWIN GOLIN.

The advertising industry has been on the alert for methods of testing the effectiveness of pre-published advertising copy. Much time, energy, and money could be saved if methods were established that would diminish the uncertainties of such present devices as public opinion polls, experts' judgments, etc. Previous studies employing the galvanic skin response apparatus to test the effectiveness of advertising copy have been encouraging.

The present study was designed to answer the following question: Will the galvanic skin response significantly differentiate among different advertising layouts involving the same product? Three products were represented by four layouts each. The ads were then presented in a Latin-square type of order to a sample of 72 university students (60 men and 12 women). Analysis of the data indicated that there were significant galvanic skin response differences within each group of ads involving the same product and a difference in responses between male and female subjects.

Survey of Employee Attitudes in a Textile Mill. ORA M. JONES.

Problem: Discover through a quantitative-qualitative analysis of employee attitudes, the intensity and interrelation of factors which are related to degree of job satisfaction in a specific textile mill.

Population: The test group consists of 447, or 75% of total mill employees.

Procedure: The method used is the interview-questionnaire type. This includes a free-answer guided interview of a sample of employees to determine areas of satisfaction and dissatisfaction; formulation of a multiple-choice questionnaire covering eight general areas, namely, Job Satisfaction, Supervision, Co-Worker, Working Conditions, Pay and Promotion, Training, Job Efficiency, and Management and factual data pertaining to the individual's background such as age, sex, etc.; pre-testing the questionnaire for mutual understanding of language; and the final administration of questionnaire in a group test situation to 358 and by mail to the remaining non-supervisory employees.

Results: Results of the quantitative-qualitative analysis are specific only to data obtained from this particular mill.

The Carding Department is significantly (significant at 1% level) lower in Job Satisfaction than the other departments, this dissatisfaction being expressed in all areas except Supervision and Pay.

A comparison of Job Satisfaction scores with various personal factors indicate that Job Satisfaction: a) increases with age up to 57 years, then decreases; b) increases with length of service; c) is inversely related to education; d) is significantly (at 1% level) higher for females; e) is not significantly related to home satisfaction. However, the younger employees with higher education in the Finishing Department and the older employees with less than fourth grade education in the Carding and Spinning Departments have the higher job satisfaction. Difference in sex is restricted largely to the Twisting and Winding Departments.

Conclusion: General conclusion is that the intensity and interrelation of variables relevant to job satisfaction are dependent upon their interaction with other factors both physical and psychological and no constant value can be assigned to a factor.

Three Piedmont Reservoirs. E. E. HUESKE.

A portion of the fisheries investigations conducted by the N. C. Wildlife Resources Commission during the summer of 1948 consisted of a fish survey of the Creedmoor, Monroe, and High Point city lakes. The primary purpose of this investigation was to determine the species of fish present, their relative abundance, and success of reproduction. This information was used as a basis for formulating a fish management plan.

Fish collections were made with the aid of gill nets and derris, 5% rotenone content. The gill nets were most effective in collecting coarse fish while the use of derris resulted in collections of a variety of sizes and species.

Creedmoor City Lake is the smallest of the three reservoirs considered. It was impounded in 1937 forming a reservoir 20 acres in size. In 1943 it was enlarged to 125 acres and again in 1946 to its present size of 200 acres. Eleven species of fish were collected including the chubsucker, yellow bullhead, bulldog pickerel, largemouth bass, warmouth, bluegill, pumpkinseed, green sunfish, black crappie, golden shiner, and top minnow. Although some stocking has been done in this lake, the fish population seemed to be the result of natural reproduction of the fish which were present in the stream when it was impounded. Pumpkinseeds were present in the greatest numbers. However, the weight of the chubsuckers and yellow bullheads was more than half of the total weight of all fish collected. The rate of reproduction had been high and regular in the black crappie and pumpkinseed, while it had been comparatively poor in the case of the largemouth bass, bluegill, and the other species collected. The management problem in the Creedmoor City Lake seemed to be that of establishing a bass population and reducing the number of crappie. More bluegills would be desirable but their increase would have to be dependent on natural conditions as the pumpkinseed were present in such large numbers. The addition of largemouth bass may give

satisfactory results, although this is doubtful because of the increasing number of crappie in the reservoir. If stocking with bass is not successful, it then would be necessary to drain the reservoir, destroy the undesirable fish, and stock on a balanced basis with largemouth bass and bluegills.

The Monroe City Lake was constructed in 1927 and is approximately 250 acres in size. Eleven species of fish were collected including the chubsucker, brown bullhead, channel catfish, chain pickerel, largemouth bass, warmouth, bluegill, pumpkinseed, robin, white crappie, and golden shiner. The pumpkinseed was by far the most abundant fish in the reservoir while the largemouth bass, bluegills, and crappie composed a comparatively small part of the fish population. The coarse fish population was not found to be excessively large. Reproduction was almost entirely lacking except in the pumpkinseed. This reservoir had been utilized very little for fishing and consequently the fish population was made up of many small fish with possibly a few large bass. The management of this reservoir involved harvesting more fish, concurrent with possibly the addition of largemouth bass in an effort to increase the average weight of the fish.

The High Point Municipal Lake is the largest of the three and was found to be in exceptionally good condition so far as the fish population was concerned. This reservoir was constructed in 1925 and is approximately 370 acres in size. The fish collections contained ten species including the yellow bullhead, white catfish, largemouth bass, warmouth, bluegill, pumpkinseed, robin, black crappie, golden shiner, and darter. The most abundant species were the largemouth bass and bluegill. Comparatively few crappie were found and almost no evidence of a coarse fish population was seen. Reproduction was satisfactory in the bass and bluegills and poor in the other species, which is a desirable situation. The rate of growth was plotted for the bass, crappie, and the bluegill. This showed a consistent growth although not unusually rapid. Because of the desirable fish population in this reservoir, the only recommendation was more fishing in order to increase the average size and weight of the fish.

It is to be noted that although these three reservoirs lie within the same geographical region and contain almost the same species of fish, each required an individual management plan because of difference in abundance of the various species of fish.

Speciation in the Field Cricket, Gryllulus assimilis *Fab.* B. B. FULTON.

The classification of the common field crickets of the genus *Gryllulus* (= *Gryllus*) has been the despair of students of American Orthoptera. Between 1775 and 1903 forty-seven New World species were described. The diagnostic characters were all extremely variable. In 1908 Lutz published a biometrical study of series from many parts of the United States and the collection of the British Museum, which included specimens from many parts of the world. Lutz concluded that no specific entities exist in the genus *Gryllus*. In 1915 Rehn and Hebard published a study of the genus in which they agreed with Lutz regarding the American field crickets but pointed out that Lutz overlooked characters of real specific value in the Old World species.

This work greatly simplified the task of identification by making it correct to

apply the binomial *Gryllus assimilis* Fab. to every specimen from Canada to Patagonia. The present study however shows that this is an over-simplification and that even within the limits of the state of North Carolina *G. assimilis* does not conform to the present day concept of a species as an interbreeding population.

In all northern states where the species has been studied, two single brooded seasonal races occur, one wintering as nymphs and the other as eggs. In North Carolina the writer has discovered four races which are distinguished by one or more physiological characters such as type of song, choice of habitat, or seasonal history. Under year-round laboratory rearing all of these races show a tendency to retain the seasonal history normal for the race. However, there was sufficient response to artificial conditions so that adults of two or more races were obtained at the same time.

When males and females of different races were paired, mating occurred and some eggs were usually laid but no offspring were produced. Observations and a few experiments seem to show a tendency on the part of males to mate with their own race when given a choice. Thus it is shown that these races are not only isolated by ecological distribution or time of maturity but are effectively prevented from crossing by some internal isolating mechanism which either preventa fertilization or the formation of a viable zygote.

Histological Observations on the Metamorphosis of Male Habrobracon. D. S. GROSCH.

Unlike the majority of holometabolous insects, the ectoparasitic wasp known in genetic literature as *Habrobracon juglandis* (Ashmead) does not accumulate a reserve in the form of a large fat body during the feeding period. Instead, the contents of the midgut lumen comprise 89% of the body volume when the larva spins itself into the cocoon. The chief structural changes in organs and appendages have been described for developmental stages (including those in the cocoon) by Seurat, Henschen, Schlüter and Hase in closely related if not identical materials. Attention in the present report is directed to such histological changes as are shown on serial sections, prepared from organism of known age, by the paraffin method.

In comparison with non-parasitic Hymenoptera (honey bee for example) a relatively long time elapses between spinning and the beginning of the pupal stage. During this preliminary period which amounts to over 50% of the time spent in the cocoon, there is an increase of the fat body in all regions through increases in individual cell size. Accompanying this there is a decrease in the midgut diameter with the cells of the larval gut wall changing from flattened pavemental to bulging columnar shapes. The fat cells grow in diameter from 60μ to over 100μ. In the abdominal region the fat cells persist into the imago while in contrast they disappear completely from the head and thorax regions during the elaboration of muscle and nerve materials. These elements are so greatly developed by the last day before eclosion that they have become the only visibly extensive histological materials in the thorax and head.

Thus it is shown that the braconid procedure differs from that more common to the insects in sequence rather than in the nature of events associated with the

utilization of the stored reserves. That is, the fat body has its greatest development *after* the quiescent period in the cocoon has begun instead of before the cocoon is spun. Nevertheless when the morphogenetic events do proceed, differences from general mechanisms reported in other Hymenoptera have not been observed. This includes disorganization and disappearance of the larval midgut, spinning glands, and Malpighian tubules, presumably to provide reserves supplemental to those available through the partial disintegration of the fat body.

The Inheritance of Ectrodactylism; a Preliminary Report. C. D. HOWELL and T. S. BARRINGER.

Fifteen cases of ectrodactylism have been discovered in one county. All cases are related to one man, Jacob, who came to America before 1750. Most of seven generations of his descendants have been traced in this study. The physical manifestations of the defect are typical of what can be found in the literature.

Eight of the cases can be traced also to two other early settlers, Mark and Solomon, both of whom are believed to have come from the same region of Germany as Jacob and at the same time. Considerable inbreeding has occurred among the descendants of these three, and the possibility of their being related is being investigated.

Ectrodactylism is generally found to be a dominant. In the present study, however, it is concluded to be due to an autosomal recessive gene. Affected cases are spotty in the genealogy. There is considerable inbreeding. Ectrodactylic fathers had twelve children by normal wives, and all children were normal. The affected persons had a total of 42 normal sibs, making an almost perfect ratio of 3 normals to 1 affected, as would be expected if both parents were heterozygous.

Work is being done to establish more connections in the family and also to connect this pedigree with three other pedigrees of ectrodactylism in the literature.

Parasitic Crustaceans from Bimini. A. S. PEARSE.

From 368 fishes of 73 species 290 parasitic copepods and 9 isopods were collected. Of the 25 species of copepods, 14 in the following genera were new: *Anuretes* (1), *Caligus* (3), *Lernanthropus* (4), *Hatschekia* (4), *Nemesis* (1), and *Cybicola* (1). From shrimps and crabs 8 species of parasites were secured. New species were found in the following genera: *Leidya* (1), and *Octalasmis* (2).

The Circulatory System of Conjoined Twin Calves. W. O. PUCKETT.

A description was given of the circulatory channels found in full-term conjoined twin calves. The animals described showed a fusion of the head and thoracic regions, a condition known as cephalothoracopagus.

Some Comments on the Study of Myrmecophiles. M. W. WING.

A definition of the term *myrmecophile* was given so as to include only those forms which actively seek out the ants. The myrmecophile-ant relationship is then a passive one from the standpoint of the ants. The number of known myrmecophilous forms is large. Also they are extremely varied, not only structurally, but also in the degree to which they have become adapted behavioristically to living

with ants. Degrees of specialization among myrmecophiles were discussed, using the order Coleoptera as an example. *Quedius* and *Atemeles* were cited as examples of a generalized and a specialized myrmecophile respectively. In the light of the large number of known myrmecophilous species, one is forced to the conclusion that ants' nests must have a great attraction for terrestrial arthropods. The greater degree of protection and amount of food available in the formicary may explain this fact, at least in part. The question naturally arises as to why the ants are so easily exploited by the myrmecophiles, which may be considered social parasites. The answer seems to be that the rather rigid devices of food, odors, textures, etc., which normally hold the ant colony together, are rather easily exploited by the more highly specialized myrmecophiles, as the behavior-patterns of the ants are not especially plastic.

An estimate of the number of known species, subspecies, and varieties of myrmecophiles has been given by various writers. Three of these estimates are especially noteworthy. They are: P. E. Wasmann (1894), 1224; W. M. Wheeler (1910), 1500 and H. Donisthorpe (1927), 5000. These figures might possibly be viewed as underestimates; two interpretations were discussed: 1) New forms are constantly being described from all areas. For example, I have recently found a new genus and species of myrmecophilous Diapriid and also a new species of the Phorid genus *Ecitomyia* (ecitophile) in North Carolina. 2) In already named animals, there is something of a tendency to discover myrmecophilous habits, as we learn more about their ecology. *Arachnophaga aldrichi* Gahan is a case in point. The facts were discussed which lead me to believe that this myrmecoid Eupelmid is a myrmecophile. However, one might discover factors to indicate that the figures are overestimates. For example, many of the forms listed in the literature as myrmecophiles often have no real relationship with the ants. Such forms are often found in ants' nests by Berlese Funnel or breeding methods, but their association with ants, if it exists, may be fortuitous. I pointed out that the term "ants' nest" has little meaning in this connection, as a very high percentage of the nest material is not normally in contact with the ants. It is thus usually necessary to study a supposed myrmecophile in an artificial nest with the ants in order to determine its status.

A good estimate of the number of described myrmecophiles in the world would require first an exhaustive compilation from the literature. Second, critical judgment would have to be exercised if only myrmecophiles were to be included. Upon the completion of my catalogue of the ants and myrmecophiles of the world, I propose to attempt such an estimate. At present purely as a guess, I suspect that Mr. Donisthorpe's figure of 5000 may be about right for the described myrmecophiles. An attempt to guess the total number of myrmecophiles (described and undescribed) would be futile; but such a figure would doubtless be many times greater than 5000, as the tropics, which are especially rich in new species have been very inadequately investigated to date.

*A Preliminary Report on the Use of Chick Embryonic Extract in the Culture of Amphibian Pigment Cells.** H. E. LEHMAN.

* Aided by a grant from the Smith Research Fund of the University of North Carolina.

Isolation techniques have proved to be particularly rewarding in the analysis of problems relating to Amphibian pigmentation. A standard method for the preparation of hanging drop cultures of Amphibian pigment cells has been described by Twitty (1945, J. Exp. Zool.) who reported the use of two media: namely, Holtfreter's standard salt solution and peritoneal fluid obtained from adult spawning newts. The latter medium has proved to be more favorable than physiological salt solutions for the differentiation of both melanophores and xanthophores in vitro. Unfortunately the quality of the fluid obtained from different animals exhibits considerable variability and this, along with the inability of always being able to obtain adequate amounts of fresh fluid when needed, make it desirable to find a substitute which would duplicate the favorable culture properties of peritoneal fluid.

Promising results along this line have been obtained from preliminary experiments in which *Amblystoma tigrinum* and *A. punctatum* pigment cells were cultured in physiological salt solutions to which chick embryonic extract was added. The extracts were prepared as follows: 4 6-day embryos, with eyes removed, were macerated in 10 cc of standard salt solution by forcing them through a fine wire grid placed at the bottom of a 10 cc syringe. The tissue brei obtained in this manner was centrifuged and the supernatant (sealed in ½ cc Pyrex ampules) was stored at 6°C. until used. Throughout the preparation, sterile precautions were observed.

Six test series have been carried out, each consisting of 20 neural crest explants in physiological salt solution, peritoneal fluid, and various dilutions of embryonic extract. The rate and degree of pigmentation obtained in media containing embryonic extract were appreciably higher than that encountered in salt solution, and in the main they compared quite favorably with the results obtained with peritoneal fluid. The degree of melanization found in the *best* cultures in peritoneal fluid was not achieved with embryonic extract; however, the differentiation of xanthophores in the latter media was very striking and appeared to be as complete as that observed under the most favorable circumstances with peritoneal fluid. The highest level of pigmentation in the experimental series was obtained when ½ to ⅔ dilutions of stock extract were used. Higher concentrations of extract appeared to inhibit the outgrowth of pro-pigment cells from the explant. Dilutions as low as 1 part stock extract to 6 parts salt solution gave visibly better chromatophore differentiation than Holtfreter's solution alone. No direct comparison has been made between the culture properties of fresh and stored extract; however, very satisfactory pigmentation was observed in one series in which 6 week old stock extract was used.

Supplementary tests and experiments are needed to test and standardize this media; however, even now it is evident that a reasonably satisfactory substitute for peritoneal fluid can be found in the use of chick embryonic extract as a culture medium designed to foster high degrees of differentiation in Amphibian pigment cells in vitro.

REINARD HARKEMA, *Secretary*.

1948–1949

466TH MEETING, OCTOBER 12, 1948

S. Y. TYREE, JR. (Chemistry): *Potassium Peroxyselenate.*

Evidence was presented in support of the existence of a potassium salt of a peroxyselenic acid. Dry potassium hydrogen selenate crystals were fluorinated. The product exhibited some oxidizing power and, on hydrolysis in hot acid solution, some reducing power. The yield was no more than five per cent in any experiment. Nevertheless, such behavior can be logically ascribed to a peroxy compound only. It is believed that such peroxyselenates (if they do exist) are very unstable in wet air and must be prepared in the absence of water. The formula assigned to the compound is $K_2Se_2O_8$. Eight references to previous literature were given.

W. A. WHITE (Geology): *Drainage Modifications in the Piedmont of North Carolina and Virginia.*

H. R. Totten, chairman of a special committee appointed to consider awards and honors, reported the recommendations of his committee as follows:

1. That the Elisha Mitchell Scientific Society do honor to the memory of Francis Preston Venable by adding to the cover and title page of each future issue of the *Journal* the statement: This society was organized in 1883 through the efforts of Francis Preston Venable.

2. That the Elisha Mitchell Scientific Society shall award each year a prize, to be known as the William Chambers Coker Award in Science, to the graduate student whose thesis or dissertation shall be adjudged the best submitted in the science division during the year.

3. This prize shall consist of a properly inscribed certificate announcing the award and fifty dollars ($50.00) in cash; the prize shall be delivered to the recipient, if possible, at the May meeting, and the recipient shall be offered a place on the program at that meeting of the Society; and the name of the recipient and title of the thesis or dissertation shall be placed on the commencement program.

4. The recipient of the award shall be selected in the following manner: Each scientific department may submit to a judging committee of this society the thesis or dissertation which the faculty of said department consider most worthy of those received since the previous award. Such recommendation and thesis or dissertation must be received by the judging committee by May 1.

5. The judging committee of the Society shall consist of the following: The Chairman of the Science Division of the University, and two other members selected by him.

J. B. BULLITT
WM. DEB. MACNIDER
H. R. TOTTEN, *Chairman*

The above recommendations were unanimously adopted.

467TH MEETING, NOVEMBER 9, 1948

H. E. LEHMAN (Zoology): *The Relationship of Donor and Host Developmental Rates to the Suppression of Pigmentation in Salamander Larvae.*

Recent studies have shown that Amphibian pigment cells which possess either an advantage in age or in rate of development are able to inhibit the differentiation of younger or less rapidly differentiating pro-pigment cells. The experiments to be reported were undertaken for the purpose of further examining this correlation. These experiments involved explantations and transplantations of neural crest and neural folds of 3 species of *Amblystoma* and 2 species of *Triturus*. These species listed in the order of increasing rates of development are: *T. rivularis, T. torosus, A. punctatum, A. mexicanum, A. tigrinum.*

When unilateral orthotopic transplantations of neural folds were made in all possible donor-host combinations between these species, it was found that the optimal condition for obtaining the most striking manifestation of pigment suppression was obtained when a relatively large, but not necessarily a maximal, difference existed between the developmental rates of donor and host chromatophores (e. g., when *T. torosus* or *T. rivularis* were combined with *A. mexicanum*). Observations on the experimental animals during the course of larval development revealed that the inhibition of pigmentation in the more slowly developing pro-pigment cells was not permanent. Though considerably delayed in their development, the slowly developing cells eventually became pigmented in appreciable numbers during late larval stages. Suppression of pigmentation of the type encountered here, accordingly, should be considered a temporary phenomenon confined largely to late embryonic and early larval periods.

Additional experiments were carried out in an attempt to expose the nature of the interactions between chromatophores of different age or rates of development which are responsible for delaying pigmentation in younger or more slowly developing pigment cells. To this end, pieces of neural folds were introduced into hanging drop cultures possessing established outgrowths of chromatophores 4 to 10 days old. It was observed that when the younger and older outgrowths differed only moderately in age, there was very little mixing of cells when the two outgrowths came in contact with one another. A fully differentiated (10-day) primary outgrowth, on the other hand, was readily overgrown by cells emigrating from a younger explant. Essentially similar results were obtained when *A. punctatum* neural crest was grafted onto the flank of *T. rivularis* hosts of graded age. On hosts of intermediate age (in which *rivularis* pro-pigment cells were partially differentiated on the flanks at the time of operation) *punctatum* melanophores did not invade the flank regions occupied by host cells. However, on older *rivularis* hosts, donor cells were able to populate the flanks and were found intermingled among fully differentiated host cells.

These results are taken to mean a) that pigment cells in the active process of differentiating are able to impede the migration of less mature cells more effectively than are fully pigmented cells, b) that if given an optimal intermediate advantage in age or rate of development, one group of pro-pigment cells will be able to prevent or delay the outgrowth of other chromatophores, and accord-

ingly c) that the degree of suppression manifested in a given instance might be directly correlated with the magnitude of difference existing between the developmental rates of donor and host pigment cells.

WILLIAM DEB. MACNIDER (Pharmacology): *Concerning the Inability of 2,3 Dithiopropanol* (BAL) *to Prevent or to Modify the Acute Renal Injury Induced by Uranium Nitrate.*

2,3 dithiopropanol (BAL) in one of a large number of chemically closely related bodies that have been developed in an attempt to find a substance which would so influence tissues as to modify the toxic action of a variety of injurious agents and primarily for gaseous substances containing arsenic. The above indicated chemical body acts with a high degree of efficiency both in preventing and relieving tissue toxicity of both arsenic bearing compounds and of bichloride of mercury.

Uranium nitrate is one of the heavy metals which acts as a toxic agent for the kidney and exercises this influence in a predominant fashion in the same segment of the renal nephron that is elected by bichloride of mercury to express its toxic influence. With this fact in mind experiments of three types were undertaken to ascertain whether or not 2,3 dithiopropanol given in the amount of 15 mgm. per kg. to dogs subcutaneously would prevent the development of the toxic action of uranium or modify or relieve it after it had developed. The three types of experiments employed were: (1) To administer to animals 15 mgm. per kg. of this substance twice a day for four days and then attempt to intoxicate the animal with 4 mgm. per kg. of uranium nitrate, the substance being given subcutaneously. (2) To induce a uranium intoxication in the dog with 4 mgm. of uranium nitrate per kg. and then attempt to modify it by the subcutaneous use of 15 mgm. of 2,3 dithiopropanol given twice a day for four days. (3) To combine these two methods of procedure to give to the third group of animals the 2,3 dithiopropanol for two days, then intoxicate the animals with 4 mgm. of uranium nitrate per kg. and then to continue the use of the protecting substance for two days after the uranium nitrate injury has established itself.

These three types of experimental procedures have indicated that the use of 2,3 dithiopropanol has no effect in preventing the toxic action of uranium nitrate or of modifying it after it has developed. Furthermore, when this substance was given before the use of uranium nitrate there is both structural and functional evidence that it intensifies the ability of uranium nitrate to injure the kidney. It would, therefore, appear that the use of 2,3 dithiopropanol has a sensitizing influence over the kidney which increases the toxic action of uranium nitrate and, in addition, the use of this substance in uranium intoxication, even though the injury from uranium is at the same site in the kidney as the toxic action of bichloride of mercury, has no protecting or remedial influence against the uranium intoxication, whereas it is very definitely effective in bichloride intoxication. It would, therefore, appear that the uranium intoxication which dominates in the proximal convolution of the renal nephron is brought about by an intracellular chemical mechanism different from that which is induced by the use of bichloride of mercury.

468TH MEETING, DECEMBER 14, 1948

EARLENE ATCHISON (Botany): *Cytological Studies in the Leguminosae.* (Published in this Journal, **65:** 118–122, 1949)

A. HUGHES BRYAN (Public Health) and B. G. GREENBERG (Institute of Statistics): *Methods for Studying the Influence of Socio-Economic Factors on the Growth of School Children.* (Published in this issue.)

469TH MEETING, JANUARY 11, 1949

A. V. MASKET (Physics): *The Measurement of Forces Resisting Armor Penetration at Ballistic Speeds.*

This paper summarizes the experimental and theoretical status of the optical chronograph developed in the course of ballistic research at the Naval Research Laboratory. The instrument, together with a simple procedure for analysis of data, is capable of yielding the position, velocity, and deceleration of a nonplastically deforming small arms projectile during the armor penetration process, which lasts from 30 to 150 microseconds. Decelerations have been observed up to 5×10^7 ft./sec.^{2} The longitudinal vibrations induced in projectiles during impact were observed by a shadow-photography technique which yields time-displacement curves from the motion of the trailing face of a projectile during penetration. The precision of the derived decelerations, about 4 per cent, is sufficient to permit the evaluation of strain-rate and inertia effects during high speed indentation by means of conical indenters at strain-rates approaching 2×10^5/sec.

H. D. BRUNER (Pharmacology): *Air Flow in Endotracheal Tubes.*

The pressure-volume flow relations of assorted endotracheal catheters were determined for the purpose of providing a means whereby the anesthetist or surgeon might select the optimum tube for the conditions in hand. These conditions include: (a) The maximum instantaneous air flow to be encountered under existing conditions in that subject. It was emphasized that there is at present no way to predict accurately what this figure is except very roughly as between 2 and 4 times the individual's minute volume. (b) The maximal negative inspiratory and positive expiratory intrapulmonary pressures which the operator considers safe. Excessive pressure of either type is definitely damaging to the lung and cardiovascular system and may be fatal. The data provide, therefore, a partial answer to the requirement in endotracheal intubation of adequate instantaneous air flow levels together with minimal trauma to the larynx as produced by increasing size of catheter.

470TH MEETING, FEBRUARY 8, 1949

K. M. BRINKHOUS (Pathology): *Some Observations on Canine Hemophilia.*

A strain of dogs with a hemorrhagic disease similar to hemophilia in man was described by Field, Rickard and Hutt in 1946. This sex-linked disease appears to have arisen as a mutation. We obtained this strain of dogs for further study. In

15 litters from the mating of heterozygous females and normal males, 35 of 62 male progeny were affected with the bleeding tendency. None of the females were bleeders. Six of eleven females tested for the heterozygous state were positive. These distributions for each sex are close to the 1:1 ratio which would be expected in a sex-linked type of inheritance.

Heretofore, affected males have died of hemorrhage in early life. Transfusions of normal blood or plasma temporarily reduce the prolonged clotting time of these animals to a normal or nearly normal range. Concomitantly, the bleeding tendency is corrected. By using transfusions during hemorrhagic episodes, fatalities have been almost completely eliminated and bleeder dogs have been reared to maturity.

Considerable variations in the severity of the bleeding tendency have been observed. Animals with a severe form of the disease bleed frequently into joints and subcutaneous tissues. In spite of repeated transfusions, permanent joint deformities and crippling have occurred. In the milder forms of the disease, no conspicuous joint deformities were observed.

Comparative studies of the clotting defect in canine and human hemophilia revealed no fundamental differences in the two diseases. Both appear to be due to a deficiency of a plasma protein which normally interacts with blood platelets to make thromboplastin available for the clotting reaction.

W. M. WHYBURN (Mathematics): *Critical Points for Function.*

Long before the discovery of the calculus, scholars recognized the importance of "critical" or "exceptional" points in all of their efforts to find and understand the laws of nature. It was seen that the occurrences of nature are in keeping with clear-cut principles which, if fully understood, would be *maximal* or *minimal.* The natural course of a river, the eventual shape of a pebble in a stream of water, the path of a planet or an electron, and countless other phenomena can best be interpreted in terms of maximizing certain quantities while either holding others constant or minimizing them.

Discovery of the calculus provided mathematical means for better describing and studying these critical phenomena. The basic laws are formulated as functions of one or more independent variables and these functions studied through use of the differentiation and integration processes. When the functions are continuous and have derivatives at each point of the range of the independent variables, the critical points of the functions occur where all of the first derivatives vanish. In the usual treatments, the functions are required to have derivatives of the second and third orders in neighborhoods of the critical points and, through non-vanishing requirements on the second derivatives, the number of critical points in a bounded portion made finite. Under these hypotheses, the functions are expanded in a Taylor's series with the remainders expressed as terms of the second order—such expansion being made in a neighborhood of each critical point. The quadratic form thus obtained is transformed into one which involves only square terms and this new form used to classify the critical points in $(n+1)$ types, where n is the number of independent variables occurring in the function.

Relations between the numbers of critical points of the different types are then established and these used to prove the existence of critical points whose discovery had not otherwise been made. Such existence results have been important factors in searches for new chemical elements, new planets, and new information about atomic structure.

The present paper characterizes critical points and studies these for functions which are assumed continuous but which are not required to possess any derivatives. The critical points may be infinite, non-isolated, and may group themselves into continua called "critical sets". Critical sets of four types are identified and relationships between the numbers of sets of these types are established.

471ST MEETING, MARCH 8, 1949

C. T. KAYLOR (Anatomy): *Specialized Tissue in the Human Heart.*

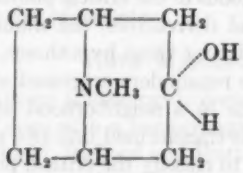
Recent work has aroused serious doubt as to the existence of any specialized tissue in human and some animal hearts. In serial sections of five young human hearts, we could see no justification for the above claims. Specialized tissue (atrio-ventricular bundle) was found to exist in all our sections. Its morphology conformed roughly to older descriptions. We found in addition many new branches of this tissue not hitherto described and in addition atrio-ventricular connections which on an anatomical basis could account for some of the modern heart syndromes.

W. H. HARTUNG (Pharmacy): cis- and trans- *TROPANOL.*

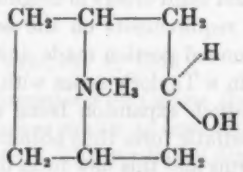
Tropanol is obtained by the hydrolysis of atropine, and pseudo-tropanol is obtained by the hydrolysis of tropacocaine. These tropanols are optically inactive but they are *cis-trans* isomers. On oxidation, in each, of the alcohol hydroxyl group, they form the same ketone, tropanone. Tropanone may be reduced depending on conditions, to either tropanol or to pseudo-tropanol.

Tropanone may be obtained also by Schöpf's modification of Robinson's "elegant" synthesis. Succinaldehyde, methylamine and acetonedicarboxylic acid, in solution and under "biological conditions", condense spontaneously to form good yields of tropanone. Reduction of tropanone with platinic oxide forms pure tropanol; reduction with sodium and ethanol forms only pseudo-tropanol.

A study of molecular models of the two isomers suggests that for the isomer in which the hydroxyl group is *cis* to the $-NCH_3$ bridge there may be expected a greater hindrance mutually between the alcoholic and amino functions; there is also greater opportunity for hydrogen bonding.



trans-Tropanol



cis-Tropanol

It would be expected, therefore, that the properties of the two isomers should be significantly different; e. g., the *cis*- ought to be a weaker base and its rate of esterification should be slower.

It was found experimentally that pseudo-tropanol, when the isomers are titrated, is the weaker base and, in a given length of time, forms a lesser yield of ester. Hence, the *cis*-configuration is assigned to pseudo-tropanol. In harmony with this conclusion are two other observations: the *cis*-isomer, in which the -OH and -NCH_3 are in closer proximity, is less hydroscopic and has a higher melting point.

The significance of this isomerism is indicated by the facts that the mandelic ester of tropanol (*trans*-) is strongly mydriatic and the benzoic ester is less anesthetic; the mandelic ester of pseudo-tropanol (*cis*-) is a weak or inactive mydriatic and the benzoic ester is a potent local anesthetic.

472ND MEETING, APRIL 12, 1949

WAYNE A. BOWERS (Physics): *The Frequency Spectrum of Crystals.*

In order to calculate the thermodynamic properties of an ideal crystal, it is necessary to know the distribution of its natural frequencies of vibration. Born and von Karman have shown how these frequencies may be calculated, but mathematical difficulties have prevented the derivation of an explicit formula for the frequency distribution except in the case of a linear chain of atoms. In recent years various approximate methods of calculating this distribution have been proposed. Blackman and others have used the distribution found numerically from a small sample of the natural frequencies; Montroll has used a method which approximates the actual distribution on the basis of the averages of various powers of the frequencies, which may be found explicitly from the Born-von Karman equations; and recently Houston has used an approximation based on the distribution of frequencies corresponding to vibrations travelling in certain particular directions in the crystal. We have derived a formula for the distribution of frequencies of the transverse vibrations of a plane square lattice, including nearest and next-nearest neighbor interactions. Although this has no direct physical interest, it is useful as a test of the various methods of approximation which have been proposed. We find that while the methods of Blackman and Montroll give fairly good approximations, Houston's method may give spurious peaks in the distribution which distort its shape considerably.

JOFFRE COE (Anthropology): *The Evolution of Aboriginal Cultures in the Carolina Piedmont.*

473RD MEETING, MAY 10, 1949

A. F. CHESTNUT (Institute of Fisheries Research): *Some Studies of the Digestive Enzymes of the Oyster (Ostrea virginica).*

Qualitative and quantitative studies were made to determine the presence of hydrolytic enzymes in extracts of the digestive diverticula, crystalline style,

masses of phagocytic cells and in filtered stomach contents of the eastern oyster. Amylolytic activity was found in all extracts with the greatest concentration in the crystalline style. Extracts of digestive diverticula and masses of phagocytic cells contained proteolytic and lipolytic activity. Proteolytic activity in general was slight. No demonstrable proteolytic or lipolytic enzymes were found in the crystalline style extracts. The presence of strong amylolytic enzymes suggests the capacity of the oyster to utilize materials rich in carbohydrates.

Dr. J. W. Lasley, Jr., *ex officio* chairman of the Committee on Awards, announced that the first winner of the William Chamber Coker Award was Dr. Earl B. Gerheim of the Department of Physiology, University of North Carolina Medical School.* Dr. J. H. Ferguson introduced Dr. Gerheim, who had flown down from Detroit to receive the award and to present his paper.

EARL B. GERHEIM (Physiology): *Staphylococcal Coagulation and Fibrinolysis.*

The classic demonstration of staphylococcal coagulation is credited to Leo Loeb (1903). Subsequent work showed that this clotting phenomenon was not mediated through the activation of prothrombin, but the basic mechanism awaited solving until Smith and Hale (1944) suggested that the staphylococcal product was the precursor (*prostaphylocoagulase*) of the active clotting agent (*staphylocoagulase*). These workers postulated that plasma contained an activator substance (*co-factor*) for *prostaphylocoagulase*, but did not identify the activator substance. The bacterial product used in our studies was prepared by modifying Tillet and Garner's (1933) technic for preparing *streptokinase*. Gerheim and Ferguson (1947) found this *co-factor* largely associated with the albumin fraction by use of ammonium sulfate fractionation technics; this was confirmed by Kaplan and Spink (1948), who in addition showed that the co-factor was associated with the globulins when alcohol was used in the fractionation.

Our next problem was to explain the incoagulability of some plasmas. This was found to be due to, (1) an inhibitor(s) which at least in part was directed against *staphylocoagulase*, (2) low *co-factor* content plus *inhibitor(s)*, and (3) *proteolysis*. No pure case of *co-factor* lack, as postulated by Smith and Hale, was found.

Early in our studies it was noted that fibrinolysis or fibrinogenolysis resulted only in the presence of a known plasma or serum proenzyme. This suggested that staphylococcal coagulation and proteolysis were distinct phenomena. Heat lability studies showed that heating at 75°C. for two hours completely destroyed the *prostaphylocoagulase* while the factor concerned in proteolysis was little altered in its activity. The latter factor we have designated *staphylokinase*. Lack (1948) reached similar conclusions as to the occurrence of the factor *staphylokinase*.

Streptokinase is highly specific for a proenzyme found in human plasma or serum. *Staphylokinase* activates a protease precursor of rabbit, guinea pig and

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dog plasma or serum, in addition to that of the human. *Staphylokinase* differs from *streptokinase* in requiring an incubation period ranging from 15–30 minutes for the development of maximal proteolytic activity.

Staphylocoagulation may be summarized as follows:

1. *Prostaphylocoagulase + co-factor = Staphylocoagulase.*
2. *Staphylocoagulase + Fibrinogen = Fibrin.*

Summary of staphylococcal proteolysis:

1. *Proenzyme + Staphylokinase = active enzyme.*
2. *Active enzyme + fibrinogen or fibrin = fibrinogenolysis or fibrinolysis.*

The Treasurer gave his report for the fiscal year, ending May 1st, and E. A. Brecht, Chairman of the Auditing Committee, said that the books had been examined and found to be correct. The report was adopted unanimously.

Dr. J. H. Ferguson, reporting for the Nominating Committee, presented the following:

President (one year)—HAROLD HOTELLING (Mathematical Statistics).
Vice-President (one year)—J. B. GRAHAM (Pathology).
Recording Secretary-Treasurer (two years)—A. E. RADFORD (Botany).

The above officers were unanimously elected.

L. L. GARNER, Sec.-Treas.

STUDIES IN THE COMPARATIVE ANATOMY OF THE CORNACEAE

By J. E. Adams

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Chapel Hill, North Carolina

The family Cornaceae offers a number of interesting problems to the systematist, both as to the relationships among its constituent genera and to its affinities with other families. Currently the family is considered to include the genera *Torricellia, Helwingia, Aucuba, Kaliphora, Cornus, Corokia, Lautea, Melanophylla, Griselinia, Mastixia, Curtisia.*

Bentham and Hooker (1867) excluded *Helwingia* which was placed in Araliaceae, but included *Alangium, Nyssa, Garrya; Lautea* and *Melanophylla* were published subsequent to 1867. Harms (1898) included all the above genera, except *Lautea*, and also *Davidia* and *Camptotheca*, grouping them in seven subfamilies. Four of these are now considered to constitute in whole or in part three distinct families, *viz:* Garryaceae, Nyssaceae, Alangiaceae. The three remaining subfamilies, *viz:* Mastixioideae, Curtisioideae, Cornoideae compose the family Cornaceae in the sense of Wangerin (1910), who divides Cornoideae into four tribes: Torricellieae (gen. *Torricellia*), Helwingieae (gen. *Helwingia*), Corneae (gen. *Aucuba, Kaliphora, Cornus, Corokia*), Griselinieae (gen. *Griselinia, Melanophylla*). *Mastixia* constitutes the subfamily Mastixioideae, *Curtisia* the subfamily Curtisioideae. Engler (1930) transfers *Corokia* to Saxifragaceae.

The family Cornaceae is traditionally allied with Nyssaceae, Alangiaceae, Araliaceae, and Umbelliferae in the order Umbellales. This alliance is based chiefly upon the few-carpeled and inferior ovary, reduced calyx, and a marked tendency toward a many-flowered, "umbellate" inflorescence. Within this order the family Cornaceae is considered the oldest by Wangerin. He regards the development of secretory ducts in the subfamily Mastixioideae a mark of relationship with Araliaceae and Umbelliferae strong enough to suggest a common ancestor for these families similar to *Mastixia*. Harms and Wangerin recognize an extraordinal relationship of Cornaceae with the shrubby Caprifoliaceae and suggest that they may have been derived from the same primitive stock. Wangerin further suggests an ultimate origin for Cornaceae in Rosales. Bessey (1915) proposes a phylogenetic treatment in essential agreement with the above. Hutchinson (1926), however, suggests the derivation of the woody Umbellales from Celastrales chiefly, and possibly also from Hamamelidales. Others have also proposed a strong celastralean relationship or have suggested that Cornaceae are not so closely allied with Araliaceae, Umbelliferae, etc., as commonly supposed. This is further suggested by the recent use of the ordinal name Cornales to include the woody Cornaceae and Nyssaceae. The varied history of the family as to generic constitution as well as the various suggestions as to phylogenetic position make the family and its presumed allies of considerable interest.

It would appear desirable, therefore, to approach the problem from another

viewpoint. It is the purpose of the present series to report the results of systematic studies on wood anatomy in a number of families, with the primary aim of evaluating the phylogenetic positions of Cornaceae and its presumed allies. The geographic distributional aspects of the broad problem are to be dealt with subsequently.

Preliminary, however, to such evaluation and the proposal of lines of interfamilial relationship, a detailed consideration must be given to the constitution of the families involved. Considering the range of anatomical variation frequently encountered within a single family, it is important that all genera and a large proportion of the species be studied, for only thus can a significant evaluation of the family be had. The sum of the known morphological data and that derived from anatomical study should make possible a more complete understanding of the phylogenetic position of the family and of its constituent genera. The function of the anatomist in problems of this sort is conceived to be twofold. First, the systematic analysis of the members of the family with a view to providing more complete knowledge of the structure of the plants makes possible the more precise definition of taxonomic units. Second, the recognition of evolutionary trends in anatomical characters provides an independent scale by which evolutionary progress of a family may be measured. Insofar as phylogenetic systems arrived at by gross morphological and by anatomical studies are in close agreement, the former is strengthened and the latter validated. Discrepancies may be expected, for it cannot be assumed that the pace of evolutionary change will be the same in all characters. Such disagreements are to be resolved by careful evaluation. That is to say, anatomical data must be considered adjunctive to gross morphology and not a substitute therefor. The value of evidence gained from wood anatomy toward the elucidation of some puzzling phylogenetic problems has been well illustrated by the work of Cox (1948, 1948a) on Ericaceae, Garratt (1933) on Myristicaceae and (1934) on Monimiaceae, and by others.

The basic studies by Bailey and Tupper (1918) and by Frost (1930, 1930a, 1931) reveal the evolutionary trends in the development of the vessel element in the secondary xylem of dicotyledons. Thus primitive vessel elements may be characterized by the following features:

1. great average length
2. small cross-sectional diameter
3. angular outline in cross-section
4. thin, even walls
5. end wall not distinct, or highly inclined to transverse axis
6. scalariform perforations with many bars
7. fully bordered scalariform pits in side wall
8. wall without tertiary thickening;

while the highly specialized elements exhibit:

1. small average length
2. large diameter in cross-section
3. circular cross-sectional outline
4. thick, uneven walls

5. distinct end wall of low inclination, or parallel to transverse axis
6. simple porous perforations
7. round, alternately arranged side wall pits with greatly reduced borders
8. tertiary wall thickening.

Between these extremes all conditions of transition may be recognized. Thus, for example, the transition from the many-barred scalariform perforation to the simple porous perforation was effected by the gradual reduction in number of bars and increase in size of apertures. Similarly, the modification of side-wall pitting from scalariform to round alternate produced, in order, intermediate types which may be described as elongate-elliptic opposite, and round opposite.

Gilbert (1940) concludes that the diffuse-porous condition of the secondary xylem is phylogenetically primitive and gave rise to the ring-porous condition. Likewise, the diffuse arrangement of xylem parenchyma is regarded as primitive, while the meta- and paratracheal arrangements are specialized.

Kribs (1935) recognizes six fundamental types of medullary rays with the Heterogeneous series primitive and the Homogeneous series derived.

Tippo (1938) and others have recognized septation of fibrous elements as a mark of specialization.

It is not to be expected that any one family will show a full range of expressions from the most primitive to the most specialized in each of the evolutionary lines. Moreover, it is not likely that evolutionary advance will necessarily proceed at a uniform rate in all such lines. Thus among the diverse and widely spread genera of Cornaceae considerable variation in wood structure is found, but the most primitive expressions within the family are not the equivalent of the most primitive expressions known. That is to say, the family shows a definite range of expression in the several phylogenetic lines; the upper and lower limits of such ranges can be determined and the genera thus placed in their appropriate relative phylogenetic positions within the family. From the same data an overall evaluation of the phylogenetic position of the family may be had with reference to related families.

MATERIALS

All genera of Cornaceae are represented in the present stu y: *Mastixia*, 7 species; *Curtisia*, 1; *Helwingia*, 3; *Griselinia*, 4; *Melanophylla*, 1; *Torricellia*, 1; *Corokia*, 2; *Lautea*, 1; *Aucuba*, 3; *Kaliphora*, 1; *Cornus*, 30. In the genus *Cornus* all subgenera, sections and subsections (except subsect. Oblongifoliae), according to Wangerin's treatment, are represented. A total of 146 specimens of well developed secondary wood was examined. These were obtained in large measure from the extensive wood collection of the Yale School of Forestry (Y) through the kindness of Dr. Robert W. Hess, from the Herbarium of the New York Botanical Garden (NY), The United States National Herbarium (US), the Herbarium of the University of North Carolina (CNC), Musée Nationale d'Histoire Naturelle, Paris (P), through the kindness of Dr. J. Leandri, and the author's personal collections.

Wood specimens were softened for sectioning by soaking in water at 60° C

(to which a few drops of Tergitol were added) for one to five days. Appropriate transverse, radial and tangential sections, cut approximately 20μ in thickness, were used for data on wood type, medullary ray type, vessel cross-sectional outline, vessel wall thickness, vessel side-wall pitting, angle of vessel end wall, tertiary vessel-wall thickening, wood parenchyma pitting. Macerations were prepared in the usual way with Jeffrey's fluid after preliminary softening with Tergitol. Safranin-stained macerations supplied data on vessel perforation, vessel diameter, vessel length, fibrous elements, fiber septation.

Numerical data, such as vessel length, vessel width, number of bars per scalariform perforation, and vessel end-wall angle were obtained from 100 readings taken from 10 or more slides. These are recorded as averages for the species, for many of which more than one specimen was studied. Averages for genera or sections were computed from those of their constituent species. Descriptive terminology conforms to commonly accepted standards.

ANATOMICAL SUMMARY FOR THE FAMILY

A number of structural features of the secondary wood are recognized for their significant variations and diagnostic value. These are listed below, with a brief statement of the family characteristic for each.

1. *Wood type.*—Cornaceae are predominantly primitively diffuse porous. Three genera show a slight to pronounced tendency to ring porosity while a fourth is definitely ring porous.

2. *Medullary Ray type.*—The primitive Heterogeneous I type predominates. One genus has the more advanced type Heterogeneous IIA exclusively, while three others have both of these in varying proportions.

3. *Vessel cross-sectional outline.*—The primitive angular outline is characteristic of three genera, the advanced circular outline is characteristic of three, while the balance show intermediate conditions.

4. *Vessel wall.*—Primitive thin, uniform vessel walls occur in approximately half of the genera; the remainder possess comparatively thick, uneven walls and are thus, in respect to this character, relatively advanced.

5. *Vessel Side-wall Pitting.*—The majority of the genera are relatively advanced in respect to this character, possessing chiefly round side-wall pits which are mostly alternately arranged or nearly so. Seven genera have, in addition, some intermediate elongate-elliptic pits. Three genera possess round alternate pits exclusively, and one has the primitive scalariform pit combined with elongate-elliptic.

6. *Vessel Perforation.*—Perforations vary in type from the scalariform with many bars to the advanced simple porous. The highest average number of bars in the nine genera having the scalariform perforation is 52, the lowest 14. Eight genera are exclusively scalariform perforate. One genus possesses simple porous perforations along with few-barred scalariform. Two genera are exclusively porous perforate. To facilitate comparison among the scalariform-perforate genera, an arbitrary point, 31, is taken as a point of division of the scalariform elements into the relatively primitive many-barred and the relatively advanced few-

barred classes. The frequency of occurrence of the few- or many-barred scalariform perforations provides an estimate of the relative position of a genus within the scalariform-perforate group.

7. *Average Vessel Element Diameter.*—The highest generic average for this character is 108 microns, the lowest, 27. Individual vessel elements, especially in the "wide" classes, vary conspicuously in width from one end to the other, frequently being rather distended or swollen in the region of the perforation. All readings for this character were, therefore, taken at the midsection of the entire vessel element, as seen in macerated material.

8. *Average Vessel Element Length.*—Variation in this character is extreme in the family ranging in generic averages from a relatively primitive 2140 microns to a relatively advanced 370 microns. All lengths were read from macerated material, extreme tip to extreme tip (Chalk and Chattaway, 1934).

9. *Ratio of Average Vessel Element Length to Average Vessel Element Diameter.*—The relatively primitive condition is expressed by a high ratio, the relatively advanced by a low. This criterion proposed by Cox (1948) has been found useful in the present instance in interpreting apparent departures from the expected relation of vessel element diameter and length in primitive and advanced classes. For example, in certain genera a comparatively large average diameter is associated with comparatively great average length, and in the genus with the smallest average vessel element length, the average diameter is by no means the greatest for the family. The positive correlation of great vessel element diameter with relative shortness of the element is not invalidated by a specific exception such as that here reported. The general usefulness in evolutionary considerations of the recognized tendency to increasing diameter with advancement in other characteristics requires that the diameter averages be considered, discrepant though they may appear to be, in the evaluation of degree of advancement of the vessel. The length-to-width ratio appears to serve well in this capacity within relatively narrow circles of affinity, and, generally, the ratios so calculated are consonant with the evaluations of evolutionary position obtained by the use of other criteria.

10. *Angle of Vessel end wall.*—Vessel end-wall angle ranges for the family from 8° to 41°, the relatively primitive lying between 8° and 19°, the relatively advanced between 30° and 41°.

11. *Tertiary Thickening of Vessel.*—Two genera show the advanced condition in the possession of spiral tertiary thickening on all vessel walls. One genus has a few vessels thus thickened, while the remaining eight genera are entirely without this feature.

12. *Wood Parenchyma Pitting.*—Pits of wood parenchyma agree in form, disposition and occurrence with the side-wall pits of vessels.

13. *Fibrous elements.*—One genus possesses the primitive fiber-tracheids exclusively; one has only the advanced libriform wood fiber, while the remaining nine genera have combinations of the two types of fibrous elements in various proportions.

14. *Fiber Septation.*—Septate fibers are a mark of comparative advancement.

One genus, that with libriform wood fibers exclusively, has almost all of these elements septate. Two other genera possess both septate and non-septate fibers, the latter in higher proportion. The remainder are wholly without septate fibrous elements.

DISCUSSION

The relatively conservative treatment of Cornaceae by Wangerin (1910) provides a broad base upon which the data derived from wood anatomy may be superimposed.

Detailed information on the anatomy of the wood of Cornaceae is largely lacking. Solereder (1908) and Hoar (1915) note the diffuse arrangement of narrow, scalariform perforate vessels, sparse and diffuse wood parenchyma as general characters of the family. Exceptions such as the simple perforations and wide vessel lumina in the specialized genera *Torricellia*, and *Kaliphora* are recorded. Wilkinson (1944) has carefully studied the vascular anatomy of the flower of certain species of *Cornus*. Other genera of the family have been similarly treated by Horne (1914).

The family Cornaceae is composed of trees and shrubs or rarely small perennial herbs with opposite or alternate, simple, exstipulate (except *Helwingia*) leaves. Flowers are small, actinomorphic, hermaphrodite or dioecious, in racemes or open panicles, ample or much reduced cymes simulating umbels or capitules. Calyx 4–5 lobed; petals 4–5, rarely 7 or 8 or absent, valvate or imbricate; stamens 4–5, alternate with petals; cushion-like epigynous disc in pistillate and perfect flowers; ovary inferior, 1–4-locular; ovules solitary in each locule, with one integument. Fruit a 1–4-celled berry or drupe. Wood mostly diffuse porous; vessels many-barred scalariform perforate or rarely simple porous perforate; wood parenchyma sparse and diffuse; rays heterogeneous.

Subfamily MASTIXIOIDEAE Harms

Small trees with opposite or alternate coriaceous leaves. Flowers hermaphrodite, small, in many-flowered terminal, dichotomous, bracteate panicles, or cymes. Calyx 4- or 5-toothed; petals 4 or 5; stamens 4 or 5, alternate with petals; ovary 1-locular, with solitary ovule and angled epigynous disc. Wood diffuse porous. Vessel elements angular in outline, the walls moderately and unevenly thickened. Perforation scalariform, many-barred. Vessel side-wall pits mostly elongate-elliptic to round. Fibrous elements chiefly fiber-tracheids, non-septate. Rays Heterogeneous I.

The genus *Mastixia* Blume, constituting the subfamily, consists of about 20 species which are grouped into two subgenera by Wangerin, *viz: Tetramastixia* and *Pentamastixia* on the basis of the number of floral parts. Danser (1935) questions the value of this character as a basis for separating subgenera. The genus occurs from western India and Ceylon throughout the East Indies to the Philippines and the Solomon Islands.

On much of the anatomical evidence *Mastixia* appears to be relatively primitive. It possesses the greatest average number of bars in the vessel perforations,

52, and the highest proportion of many-barred (over 30) plates, 100%, to be found in the entire family. The end-wall angle is the lowest for the family, 8°, and the vessel elements average longest, 2140μ. Side-wall pitting, although chiefly round and elongate-elliptic, is frequently scalariform. The primitive aspect is further suggested by the Heterogeneous I rays, striking angularity of vessel outline and predominance of fiber-tracheids over libriform elements. Advanced features are not wanting, however. Most importantly, the average vessel diameter, 108μ, is the largest for Cornaceae. Ratio of average vessel element length to width is nearly 20:1.

Notable among the advanced morphological features of *Mastixia* is the unilocular ovary, a feature deserving considerable weight in estimating the phylogenetic position of the genus. The occurrence of 4- or 5-merous flowers about equally in the genus suggests a relatively recent and perhaps progressing derivation. The multiflorous open panicle is a mark of primitiveness within the family.

Mastixia would appear to have evolved more rapidly in floral structure than in anatomical features. The exceptionally great average vessel diameter is the chief anatomical feature to indicate an advance comparable to that of the flower. The average of vessel element length-width ratios, 20:1, when treated comparatively with that of other genera places *Mastixia* in a relatively primitive position in Cornaceae.

The variation of vessel characteristics among certain of the species of *Mastixia* examined are set forth in the following table.

M. trichotoma Blume (Y #31020—*Janssonius 3100a*); *M. rostrata* Blume (Y #31022—*Janssonius 2309a*); *M. caudatifolia* Merr. (Y #20240—*Foster*); *M. tetrandra* (Wight) Clarke (US—*Thwaites 2441*, isotype); *M. Korthalsiana* Wang. (Y #15458—*Van de Koppel 4085*); *M. philippinensis* Wang. (Y #34219); *M. pentandra* Blume (US—*Kajewski 2086*).

	M. trichotoma	*M. rostrata*	*M. caudatifolia*	*M. Korthalsiana*	*M. philippinensis*
Vessel length					
Max.	2128μ	2397μ	2652μ	3144μ	3668μ
Min.	1375μ	1408μ	1680μ	1932μ	1738μ
Aver.	1677μ	1763μ	2146μ	2422μ	2414μ
Vessel diam.					
Max.	145μ	131μ	100μ	155μ	134μ
Min.	77μ	93μ	65μ	99μ	90μ
Aver.	105μ	115μ	81μ	120μ	110μ
Ratio	16:1	15:1	26:1	20:1	21:1
Perforation					
% scal. 31 + bars	100	100	100	100	100
% scal. 30 − bars	0	0	0	0	0
Av. no. bars	48	44	51	48	66

Omitted from the above table are *M. pentandra* and *M. tetrandra* for which only very youthful material was available. It is interesting to note, however, that whereas the vessel dimensions are considerably lower the vessel element length-to-width ratio is consistent with those cited above, being 23:1 for the former and 17:1 for the latter. With the exception of the very high ratio for *M. caudatifolia* which is tetramerous, the generally higher ratios of the pentamerous

species suggests a more primitive standing for this group. This is, of course, a reflection of the significantly greater average length of the vessel elements in the latter group. Similarly, the average number of bars per perforation plate tends to be higher in the pentamerous species examined. However, it is questionable whether such correlations would hold in an extended series of observations, in view of Danser's inability to find correlative differences between many of the tetramerous and pentamerous species, and his occasional finding of both floral conditions in the same species.

Subfamily CURTISIOIDEAE Harms

Trees with opposite coriaceous leaves. Flowers hermaphrodite, minute, in many-flowered terminal dichotomous, bracteate panicles. Calyx 4-lobed; petals 4; stamens 4, alternate with petals; ovary 4-locular, with solitary ovule in each cell and angled epigynous disc. Wood diffuse porous. Vessel elements circular in outline, the walls moderately and unevenly thickened. Perforation scalariform, mostly few-barred. Vessel side-wall pits mostly round. Fibrous elements chiefly fiber-tracheids, non-septate. Rays of type Heterogeneous I.

The genus *Curtisia* Ait., constituting the subfamily Curtisioideae is represented by a single species, *C. faginea* Ait., endemic to South Africa.

Curtisia seems, on anatomical evidence, to occupy an equivocal position within the family. The average vessel element length is the second greatest in Cornaceae, while the average vessel element diameter is almost exactly the average for the family. Vessel element length-to-width ratio is 19:1. In other respects the vessel elements are more derived. Thus, the perforation plates average 26 bars, although 30% of the plates have 31 or more bars. Similarly the end-wall angle averages 24° which is above the 19° average for the family. Side-wall pitting is predominantly round with a few elements bearing some pits of the more primitive elongate-elliptic type. The fibrous elements are chiefly the more primitive fiber-tracheids. In flower structure also, a combination of relatively primitive and advanced characters occurs, namely the 4-locular ovary and tetramery.

Evaluation of such conflicting evidence is difficult, but it does appear that the primitive features carry a somewhat greater weight, and a relatively primitive position is thus assigned to the subfamily. *Curtisia* serves well to illustrate the unevenness of evolutionary rate among the complex of characters both anatomical and morphological.

The variation of vessel characteristics in *Curtisia faginea* are shown in following table.

C. faginea Ait. (Y #14934—Forestry Dept., Pretoria. # Ind. 807; NY—ex Herb. Kew; US—*Swynnerton 637*).

Vessel length	
Max.	1539μ
Min.	851μ
Av.	1207μ
Vessel diam.	
Max.	120μ

Min.	32μ
Av.	63μ
Ratio	19:1
Perforation	
% Scal. 31 + bars	30
% Scal. 30 − bars	70
Av. no. bars	26

Subfamily CORNOIDEAE Harms

Trees, shrubs or rarely perennial herbs with opposite or alternate, mostly exstipulate leaves. Flowers hermaphrodite or dioecious, small, in racemes, panicles, umbels, or capitate clusters. Calyx 4–5 (rarely 7) lobes, adnate to ovary; petals 4–5 (rarely 3 or 7) or absent, valvate or imbricate; stamens 4–7, alternate with petals; ovary 1–4-locular with ovules solitary in locules, central or epigynous disc angled or rounded, prominently fleshy or obscure. Wood diffuse porous, rarely ring porous. Vessel elements angular to round in outline, the walls thin and even to thick and uneven. Perforation many- or few-barred scalariform or simple porous. Vessel side-wall pits elongate-elliptic to round (rarely scalariform). Fibrous elements fiber-tracheids to libriform fibers, rarely septate. Rays Heterogeneous I or rarely IIA.

The subfamily exhibits a wide range of morphological and anatomical variation. Some of the most primitive features and the most advanced shown by the family are found among the nine genera of this subfamily. Wangerin recognizes four tribes, *viz:* Torricellieae, Helwingieae, Griselinieae, and Corneae. In the light of the present study, it has seemed desirable to propose two new tribes, *viz:* Aucubeae consisting of the genus *Aucuba*, and Kaliphoreae consisting of the genus *Kaliphora*, both included in Corneae of Wangerin.

Tribe CORNEAE Wangerin

Trees or shrubs, very rarely perennial herbs, with opposite, rarely alternate, leaves. Flowers hermaphrodite or very rarely dioecious, with 4 or 5 (rarely 6–8) petals and stamens; on non-articulate pedicels, singly on short branches, or in loose or compact cymes, panicles, or small heads. Ovary 1- to 4-locular. Fruit a 1- to 4-seeded drupe. Wood diffuse porous. Vessel elements angular to angular-rounded with thin even walls and elongate-elliptic to round side-wall pits. Perforations scalariform, many- or few-barred. Rays Heterogenous I and rarely transitional to Heterogeneous IIA.

The tribe Corneae as here considered includes *Cornus* L., *Corokia* A. Cunningh., and *Lautea* F. Brown.

Lautea with two species is endemic to the island of Rapa in the South Pacific. Calyx lobes, petals and stamens vary in number from 5 to 8. The ovary is 2- to 4-locular. Anatomically the genus appears relatively primitive with a vessel length-width ratio of 21:1 and sharply angular vessel outline. Brown (1928) reports the presence of tertiary spiral thickening on vessel walls which is not confirmed by the present study. The fibrous elements, predominantly fiber-tracheids, are non-septate although Brown reports septa present. In the vessel perforations, however, the genus occupies a comparatively advanced position. The scalariform perforations are exclusively of the few-barred type, the average

number of bars being 20. Vessel side-wall pitting is predominantly round, but a conspicuous proportion of the vessels have the more primitive elongate-elliptic type. End-wall angle is low, 13°.

Brown is correct in assigning a primitive position within the tribe to *Lautea*. This he does on the basis of the high and variable number of flower parts, including the multilocular ovary, as well as anatomical data among which he emphasizes the extreme narrowness of vessel segments (reporting 31μ average).

Variations in vessel characteristics are shown in the following table.

Lautea collenettii (Riley) F. Brown, (Y #37337—*St. John 3696*); *L. stokesiana* F. Brown, (Y #24281—*Stokes 433*). These are the same species; the former is the valid name.

Vessel length	
Max.	1015μ
Min.	687μ
Av.	798μ
Vessel diam.	
Max.	54μ
Min.	26μ
Av.	38μ
Ratio	21:1
Perforation	
% Scal. 31 + bars	0
% Scal. 30 − bars	100
Av. no. bars	20

Corokia with three species in New Zealand and Chatham Is. is closely related to *Lautea* from which it differs chiefly in having the flower parts stabilized in 5's, with a 1- or occasionally 2-locular ovary. The closeness of relationship is reflected also in anatomical features. Thus vessel element measurements and structural features such as angular cross-sectional outline, thin even walls, angle of end wall (13°), and perforation as well as ray type are in close agreement with those of *Lautea*. The vessel length-width ratio for *Corokia* is 24:1, a relatively more primitive condition. The average vessel diameter here reported is about twice the figure cited for *Corokia* by Solereder. It appears probable that his figure (13μ) was taken from extremely youthful material of *C. buddleioides*. Fibrous elements appear to be exclusively fiber-tracheids and are non-septate.

From the facts of floral morphology and distribution, Brown (1928) concludes, with special emphasis upon the reduced ovary (cf. Mueller, 1864; Wangerin, 1910), that *Corokia* is a possible derivative of *Lautea*. With this view, the anatomical evidence seems not greatly inconsistent.

Variations in anatomical characters are shown in the following table.

Corokia cotoneaster Raoul (US—*Cheeseman*); *C. buddleioides* A. Cunningh. (US—Wilkes Exped.)

	C. cotoneaster	*C. buddleioides*
Vessel length.		
Max.	884μ	812μ
Min.	399μ	524μ
Av.	641μ	641μ

Vessel diam.		
Max.	26μ	38μ
Min.	20μ	24μ
Av.	23μ	31μ
Ratio	27:1	21:1
Perforation		
% Scal. 31 + bars	0	0
% Scal. 30 − bars	100	100
Av. no. bars	18	23

Cornus, with about 50 species, is the most widely spread member of the family; it occurs throughout the north temperate regions and two species are montane tropical in South America and Africa.

Trees, shrubs or rarely perennial herbs with opposite or rarely alternate leaves and small, hermaphrodite or rarely dioecious flowers in open, usually ebracteate, or much condensed, often involucrate cymes resembling umbels or capitules. Petals and stamens, 4; ovary 2-locular; drupe sometimes 1-seeded.

Wangerin's treatment of *Cornus* recognizes seven subgenera, two sections and four subsections. Twenty-seven species, some represented by several specimens were available for study. For the North American species the treatment of Rickett (1945) is followed as to synonymy.

Variation in anatomical detail is considerable, as may be expected, in this large genus. The tables following show such variations among representative species in each subgenus.

Subgen. *Thelycrania: C. alternifolia* L. (Y #40158—*Hicock;* auth. collection); *C. controversa* Hemsl. (Y #14602—Inst. Wood Tech., Tokyo); *C. parviflora* Chien (Y #21905—*Y. Tang*); *C. occidentalis* Cov. (Y #26954—*Quick;* Y. #11525, as *C. pubescens* Nutt.—U. S. For. Serv.); *C. stricta* Lam. (Y #11888—U. S. For. Serv.; CNC #11250; Y #11912, as *C. obliqua* Raf.—*Kribs*); C. *stolonifera* Michx. (Y #14863—*Detwiler 138;* CNC #15969); *C. asperifolia* Michx. (Y #40652—*Opdyke;* CNC #11857; #3867; *Brush 10220*); *C. rugosa* Lam. (Y #27189, as *C. circinata* L'Her.—U. of Mich. Biol. Sta.; CNC #8476); *C. racemosa* Lam. (Y #39338, as *C. candidissima* Mill.—*Hickock;* CNC #3898, as *C. candidissima* Marsh.; #14284, as *C. paniculata* L'Her.; #1854; #9722, as *C. paniculata* L'Her.); *C. peruviana* Macbr. (Y #31992—*Rimback*); X *C. californica* Mey. (Y #27285—*Webber*); *C. macrophylla* Wall. (Y #40801—cultiv., *Graves*); *C. Walterii* Wang. (Y #23066—Fan. Mem. Inst. Biol #13); *C. sanguinea* L. (Y #40800—cultiv., *Graves*); *C. amomum* Mill, (Y #24416—*Marco 24;* CNC #11069; auth. collection.

Subgen. *Macrocarpium: C. chinensis* Wang. (Y # 21808—*Y. Tang*); *C. officinalis* Sieb. & Zucc. (Y #32297—*Yamabayashi*); *C. mas* L. (Y #12679—cultiv., *Mulliner;* cultiv., auth. collection).

Subgen. *Afrocrania: C. volkensii* Harms (Y #27557—*Schieben 3884*).

Subgen. *Discocrania: C. disciflora* Moc. & Sesse (Y #38408—*Stork 4194*).

Subgen. *Arctocrania: C. canadensis* L. (CNC—*Mathews 282;* #12955—*Coker*).

Subgen. *Benthamidia: C. florida* L. (Y #40248—*Hess 157;* auth. collection); *C. nuttallii* Audub. (Y #19917—Field Mus. #73428; CNC—*Crum 2110*).

Subgen. *Benthamia: C. hongkongensis* Hemsl. (Y #21971—*Y. Tang*); *C. kousa* Buerg.(Y #29346—cultiv., Arn. Arboret. #13122-B); *C. capitata* Wall. (Y #21912—*Y. Tang.*)

	C. alterni-folia	*C. contro-versa*	*C. brachy-poda*	*C. parvi-flora*	*C. occidenti-alis*
Vessel length					
Max.	1310μ	1441μ	1441μ	1951μ	1427μ
Min.	707μ	877μ	982μ	1506μ	491μ
Av.	813μ	1113μ	1225μ	1727μ	915μ
Vessel diam.					
Max.	63μ	124μ	133μ	69μ	116μ
Min.	31μ	77μ	86μ	46μ	31μ
Av.	45μ	97μ	69μ	60μ	74μ
Ratio	18:1	11.4:1	17.7:1	28:1	12.6:1
Perforation					
% Scal. 31 + bars	100	100	0	100	0
% Scal. 30 − bars	0	0	100	0	100
Av. no. bars	43	34	24	62	28

	C. stricta	*C. stolon-ifera*	*C. asperi-folia*	*C. rugosa*	*C. racemosa*
Vessel length					
Max.	1146μ	989μ	1251μ	995μ	1179μ
Min.	497μ	524μ	668μ	609μ	815μ
Av.	776μ	796μ	966μ	801μ	857μ
Vessel diam.					
Max.	82μ	77μ	89μ	79μ	62μ
Min.	40μ	31μ	31μ	43μ	38μ
Av.	53μ	45μ	49μ	59μ	49μ
Ratio	14.7:1	18.8:1	21:1	13.5:1	17:1
Perforation					
% Scal. 31 + bars	50	54	53	58	0
% Scal. 30 − bars	50	46	47	42	100
Av. no. bars	32	31	37	30	25

	C. peruviana	X *C. cali-fornica*	*C. macro-phylla*	*C. Walteri*	*C. sanguinea*
Vessel length					
Max.	1617μ	1087μ	884μ	1310μ	1080μ
Min.	982μ	622μ	589μ	720μ	524μ
Av.	1382μ	812μ	745μ	953μ	743μ
Vessel diam.					
Max.	102μ	68μ	77μ	116μ	77μ
Min.	57μ	35μ	38μ	77μ	37μ
Av.	79μ	56μ	53μ	97μ	57μ
Ratio	17.5:1	14.5:1	13.9:1	9.8:1	12.8:1
Perforation.					
% Scal. 31 + bars	28	0	0	0	0
% Scal. 30 − bars	72	100	100	100	100
Av. no. bars	27	26	21	19	22

	C. amomum	*C. chinensis*	*C. offici-nalis*	*C. mas*	*C. volkensii*
Vessel length					
Max.	1192μ	1689μ	1362μ	1637μ	1820μ
Min.	569μ	849μ	753μ	641μ	1061μ
Av.	825μ	1316μ	1040μ	911μ	1451μ
Vessel diam.					
Max.	65μ	79μ	62μ	93μ	134μ

Min.	38μ	51μ	32μ	31μ	55μ
Av.	52μ	68μ	47μ	52μ	93μ
Ratio	15.8:1	19.3:1	22:1	18:1	15.6:1
Perforation					
% Scal. 31 + bars	50	100	46	12	100
% Scal. 30 − bars	50	0	54	88	0
Av. no. bars	30	47	31	27	44

	C. disciflora	*C. canadensis*	*C. florida*	*C. nuttallii*
Vessel length				
Max.	1748μ	602μ	1244μ	1414μ
Min.	799μ	209μ	825μ	1113μ
Av.	1310μ	370μ	1030μ	1195μ
Vessel diam.				
Max.	155μ	37μ	85μ	116μ
Min.	88μ	23μ	57μ	83μ
Av.	119μ	31μ	78μ	97μ
Ratio	11:1	12:1	13.2:1	12.3:1
Perforation				
% Scal. 31 + bars	75	0	94	63
% Scal. 30 − bars	25	100	6	37
Av. no. bars	31	17	41	31

	C. hongkongensis	*C. kousa*	*C. capitata*
Vessel length			
Max.	1951μ	1519μ	1578μ
Min.	1270μ	858μ	694μ
Av.	1578μ	1231μ	1028μ
Vessel diam.			
Max.	96μ	77μ	93μ
Min.	60μ	46μ	54μ
Av.	80μ	55μ	74μ
Ratio	19.8:1	22.1:1	13.9:1
Perforation			
% Scal. 31 + bars	90	100	100
% Scal. 30 − bars	10	0	0
Av. no. bars	48	49	47

The subgenera of *Cornus* may be arranged in two series on the basis of inflorescence. One of these, consisting of the subgenera *Thelycrania*, *Afrocrania*, and *Arctocrania*, is characterized by an ample and open, or small and more or less congested, obviously cymose inflorescence. The other, consisting of *Macrocarpium*, *Benthamia*, *Benthamidia*, and *Discocrania*, is characterized by inflorescence which has attained forms simulating very closely umbels and capitules (Rickett, 1944). The series here described are not necessarily regarded as groups of especially closely related subgenera, but as convenient expressions of degree of reduction of inflorescence. However, a linear arrangement of the subgenera in order of progressing reduction does not, in view of anatomical data, express adequately the relationships among the subgenera.

The subgenus *Thelycrania* embracing a majority of the species of *Cornus* is represented in the present study by sixteen out of a total of thirty-two species. Included in this list are representatives of all sections and subsections (except subsect. Oblongifoliae, with one species) according to the treatment of Wangerin.

On character of inflorescence, *Thelycrania* is clearly the most primitive subgenus. When compared anatomically with all the remaining subgenera (which display a greater or less reduction of inflorescence) taken as a group, its relative primitiveness is less clearly marked but plainly suggested.

	Av. no. bars	*Av. ves. length*	*Av. ves. diam.*	*Av. ves. L-W ratio*	*Av. fiber length*
Thelycrania	36	1000	65	16.5:1	1669
Other subgen.	35	1087	74	15.8:1	1321

Individual comparison of *Thelycrania* with the other subgenera, however, reveals that it is preceded in primitiveness of anatomical expression by two other subgenera, *viz.*, *Macrocarpium* and *Benthamia*. This is somewhat surprising in view of the significantly advanced morphological characters of these subgenera, the former possessing an "umbellate" type of inflorescence and the latter a "capitate" with petaloid involucre and syncarpous fruit.

The subgenus *Macrocarpium* is anatomically the most primitive. Average number of bars per perforation is 35, equal to the average for *Cornus;* 53% of the perforations have more than 31 bars. Vessel element length is about equal to the average for the genus, but the diameter is considerably lower, giving a vessel length-width ratio of nearly 20:1, highest for *Cornus*. Fibrous elements, predominantly fiber-tracheids, are among the longest in the genus, exceeding the average for the genus by about 200μ. Wood parenchyma, although predominantly diffuse, occurs sparingly in thin metatracheal bands. Although anatomically more primitive than *Thelycrania*, *Macrocarpium* could not represent the direct source of that subgenus or others which possess a more primitive inflorescence pattern. However, it is both anatomically and morphologically primitive with respect to the other three subgenera in the "umbellate-capitate" series and may be conceived as a probable source of them. The tendency to petaloidy of the involucral bracts exhibited by one species, suggests *Macrocarpium* as an equally likely source of conspicuous petaloidy where it occurs in the "capitate" subgenera.

The subgenus *Benthamidia* with two American species represents an advancement over *Macrocarpium* in both anatomical and morphological features. Although average vessel element length, 1112μ, is slightly greater than the average for the genus, average vessel width, 87μ, is considerably greater, giving a length-width ratio of about 13:1. The average number of bars per scalariform perforation plate, 36, is about equal to the average for the genus, although about 78% of the plates show more than 31 bars. Fibrous elements are about equally fiber-tracheids and libriform elements whose length is somewhat less than the genus average. The small "capitate" terminal inflorescence of sessile flowers is clearly derivative from the "umbellate" type of *Macrocarpium*. The conspicuous petaloid involucre, a mark of specialization in *Cornus*, appears to have arisen rather independently in various subgeneric groups. In the present instance it may well have developed from one similar to the subpetaloid involucre of *C. sessilis*.

Anatomically the subgenus *Benthamia* with three Asiatic species is little advanced over *Macrocarpium* from which it may have been derived independently of the other petaloid-bracteate subgenus, *Benthamidia*. Its relatively primitive

position is shown by vessel elements which are some 200μ longer than average for the genus and considerably narrower, 69μ, giving a high length-width ratio of almost 19:1. Average number of bars per perforation plate is 48, highest for the genus, with about 97% of the plates having in excess of 31 bars. One species, *C. capitata* Wall., with exceptionally short vessel segments has a length-width ratio of 14, but otherwise is in agreement. Fibrous elements which are almost wholly fiber-tracheids average about 200μ longer than the average for the genus. *C. kousa* displays a few small metatracheal bands of wood parenchyma. The conspicuously petaloid-bracteate and "capitate" inflorescence of this subgenus appears to ally it closely with *Benthamidia* over which it shows a marked advance in the fusion of its drupes at maturity into a fleshy syncarpium. However, in view of the strongly primitive anatomical condition of *Benthamia*, it appears reasonable to assume its derivation rather more directly from *Macrocarpium* by the development of a condensed "capitate" inflorescence and of a petaloid involucre quite independently from *Benthamidia*, and possibly earlier. The modified condition of the fruits, then, is an advanced feature not attained by the anatomically more highly specialized *Benthamidia*.

Discocrania, a subgenus with one or two species, presents a mixed picture. Anatomically it is highly specialized in some features and rather primitive in others. Average vessel element length is 1310μ, considerably above the average for the genus, but the length-width ratio is very low (11:1) by virtue of the great average width, 119μ, of the vessel elements. Bars of the perforation plates average 31 in number, but 75% of the plates possess in excess of 31 bars. Fibrous elements, which are chiefly fiber-tracheids with some libriform fibers, are somewhat longer than the average. Medullary ray type is unique for this series, being of type Heterogeneous II B. The condensed, "capitate" inflorescence is a morphological advance associating *Discocrania* with *Benthamidia* and *Benthamia*, but the involucre consists of small herbaceous, promptly deciduous bracts, which suggests affinity more directly with *Macrocarpium*. The advanced type of medullary ray and low vessel length-width ratio appear to require the placement of *Discocrania* as the most advanced of the capitate subgenera notwithstanding its relatively primitive involucre. It appears reasonable to suppose, therefore, that it may have originated at a point along the line from *Macrocarpium* to *Benthamidia*, probably rather close to the former.

The subgenus *Afrocrania* with one species in the eastern African highlands is the only representative of the genus on that continent. Vessel elements are considerably longer, 1451μ, than the average for the genus but are, second to *Discocrania*, the widest, 93μ, thus giving a relatively low vessel length-width ratio of 15.6:1. The number of bars per perforation plate is unexpectedly high, averaging 44. Angle of the end wall to side wall is high, 22°. Vessel outline is decidedly round and the walls conspicuously and unevenly thickened. In arrangement, the vessels tend to occur in small multiples, although the usual solitary arrangement predominates. Fibrous elements which are only slightly longer than the genus average are predominantly libriform, while the pits of the fiber-tracheids are much reduced. Morphological features of a derived character are the dioecism

of the flowers and the comparative congestion of the inflorescence. However, the inflorescence does not attain the degree of reduction shown by the essentially umbellate inflorescence of *Macrocarpium*, but clearly resembles the more primitive open cymes of *Thelycrania*, except that the latter is ebracteate. The bracts of the inflorescence are herbaceous and promptly deciduous. These relatively primitive morphological features suggest an origin relatively close to, but below, *Macrocarpium* while the dioecism, congestion of the cyme, and advanced anatomical features suggest an attained evolutionary position well above that group.

The subgenus *Arctocrania* with two boreal circumpolar species is unique in the genus in possessing an herbaceous stem and a commonly unilocular 1-seeded fruit. Anatomical data suggest a high degree of specialization. Vessel elements are the shortest in the genus, 370μ, and although they are also the narrowest, the length-width ratio is, next to *Discocrania*, the lowest. Number of bars per perforation plate is lowest for the genus, 17. The inflorescence is a much reduced cyme subtended by petaloid bracts, but it does not approach, in reduction, the typical umbellate form of *Macrocarpium*, although exceeding that of *Afrocrania*. To the extent that the inflorescence of *Arctocrania* thus shows a more primitive condition than that of *Macrocarpium*, its origin might be considered to be below but close to that subgenus. Derivation from *Benthamidia* is unlikely since the inflorescence of *Arctocrania* is of a more primitive type. Its evolutionary specialization has culminated in the herbaceous habit, the attainment independently of a petaloid involucre, and a high degree of anatomical specialization.

A graphic presentation of the probable interrelationship of the subgeneric groups is set forth in figure 1. The occurrence within the genus *Cornus* of a number of essentially independent evolutionary trends in morphological characters has resulted in the recognition of several definable units consisting of groups of species. These groups of species have variously been accorded generic, subgeneric, and sectional rank by authors. Whatever the taxonomic rank accorded such species groups, it appears that the phylogenetic development of the genus has not been a straight-line, step-by-step process throughout, but essentially a fanning out of derived groups of species from some less specialized form. Such a hypothetical ancestor probably did not resemble closely any of the modern species, but contained potentialities for the subsequent derivation of all of them. Judged upon morphological grounds, the large subgenus *Thelycrania*, including the alternate-leaved *C. controversa* and *C. alternifolia*, should be assigned a most primitive position. Its inflorescence, usually an ample, ebracteate cyme, is clearly primitive. Such a cyme may be subject to consolidation or reduction, resulting in such degrees of congestion and reduction of inflorescence as characterize the subgenera *Afrocrania* and *Arctocrania*, or through further reduction to give the "umbellate" inflorescence of *Macrocarpium* and, ultimately, the "capitate" type of *Benthamia*, *Benthamidia*, and *Discocrania*. From the anatomical picture, however, it must be clear that the subgenera could not have arisen in a straight line as the progressive reduction of inflorescence suggests. This view seems to be supported also by the fact that, although the reduced types of inflorescence are

involucrate, the involucres behave variously and assume forms that are not in general directly related to degree of inflorescence reduction. Nor does involucral type bear a constant relation to degree of anatomical specialization.

Therefore, *Macrocarpium* which is anatomically less specialized but morphologically more advanced than *Thelycrania* may be the oldest of the modern species groups which resulted from a very rapid reduction of inflorescence from a loosely cymose type to "umbellate", while retaining its primitive anatomical characters. The modern *Thelycrania* represents a parallel offshoot from a primitive stock, whose chief evolutionary progress has been marked by comparatively great

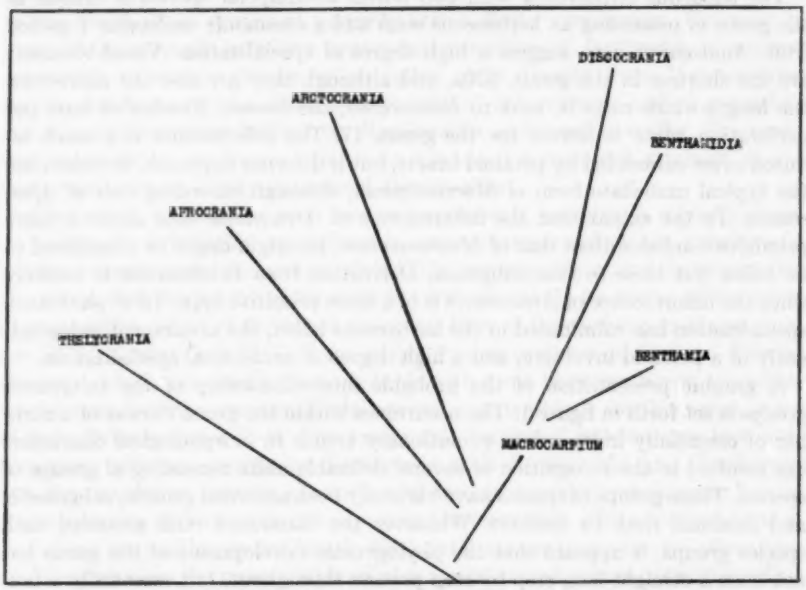

FIG. 1. Phylogenetic relationships among subgenera of *Cornus*

anatomical advance but little morphological change. The low order of anatomical specialization of *Benthamia*, coupled with its highly derived, "capitate" and petaloid-involucrate inflorescence and syncarpous fruit, place it as an early derivative of *Macrocarpium*, which in development of the syncarpous fruit has assumed a unique position within the genus. *Benthamidia*, in which the inflorescence is also "capitate" and petaloid-involucrate, but whose drupes are free, could not have been derived from the anatomically more primitive *Benthamia*, but must have had its source in *Macrocarpium*. *Discocrania*, with a "capitate" and herbaceous-involucrate inflorescence, is anatomically the most specialized. Its origin may be thought to have been a point along the line from *Macrocarpium* to *Benthamidia* subsequent to the reduction of inflorescence to the "capitate" condition. *Afrocrania* and *Arctocrania*, with reduced and involucrate inflores-

cence, the latter with petaloid bracts, originated at a time subsequent to the divergence of *Macrocarpium* and *Thelycrania* from the parent stock, but prior to reduction of the primitive inflorescence to the "umbellate" form.

Of interest in this connection are the results of investigations of chromosome numbers in the genus, by Dermen (1932) and others. From observations of species representing five of the subgenera, Dermen concludes that those with the lowest chromosome number (n = 9) are primitive. By segmentation and duplication higher numbers (n = 10, n = 11, n = 22) are obtained. On this evidence, *Macrocarpium* (*C. mas, C. officinalis:* n = 9) is primitive, *Thelycrania* (*C. alternifolia, C. controversa:* n = 10; *C. amomum, C. rugosa,* etc.: n = 11) is derived, *Benthamia* (*C. capitata, C. kousa:* n = 11) and *Benthamidia* (*C. florida, C. nuttallii:* n = 11) are derived. Dermen suggests the derivation of *C. canadensis* (n = 22) of the subgenus *Arctocrania* from a form like *C. florida* by duplication. However, in *C. suecica* of *Arctocrania* n = 11 (Darlington and Janaki Ammal, 1945). It seems not unreasonable to conceive of a primitive "pro-*Cornus*" stock, *Thelycrania*-like in inflorescence, in which n = 9.

Tribe AUCUBEAE Trib. nov.

Small evergreen trees or shrubs with opposite, shining coriaceous leaves. Flowers tetramerous, dioecious, on 2-bracteolate, articulate pedicels in axillary or terminal dichotomous panicles. Ovary 1-celled, with 1 ovule. Fruit a scarlet berry. Wood diffuse porous and tending to semi-ring porous. Vessel elements angular to slightly rounded with thin, even walls, spiral tertiary thickening and elongate-elliptic to round side-wall pitting. Perforations scalariform, mostly many-barred. Rays Heterogenous I and Heterogenous IIA.

This tribe consists of the single genus *Aucuba* Thunb. with three closely related species of Japan, China and the eastern Himalayas. Wangerin includes *Aucuba* in the Tribe Corneae. In morphological and anatomical characters, *Aucuba* presents a picture which seems best viewed as the culmination of a line of evolution apart from *Cornus, Corokia,* and *Lautea.* Its coriaceous leaves, long-persistent epidermis and green stems give it a distinctive aspect, although the stems of some *Cornus* species retain the epidermis and remain green for a few years, and *Corokia* and *Kaliphora* have evergreen coriaceous leaves. Articulated pedicels are found elsewhere in the subfamily only in Torricellieae and Griselinieae, the latter also sharing the baccate fruit. The tetramerous, dioecious flowers and 1-locular ovary are indicative of considerable morphological advancement. Anatomically, *Aucuba* displays a mixture of primitive and derived characters and conditions. In number of bars per perforation plate it stands in the second most primitive position within the family, with an average of 45, with about 74% of the plates having more than 31 bars. Vessel element end walls incline to the long axis at an average angle of 12°. Vessel elements average 972μ, but this moderate length is associated with very small average diameter, 37μ, giving a vessel length-width ratio averaging slightly more than 26:1. Vessel outline in cross section is predominantly angular, with the walls thin and even. Fibrous elements are about equally fiber-tracheids and libriform fibers. Coupled with these relatively primitive features are derived ones which indicate a striking unevenness in

evolutionary rate. Thus, the wood exhibits a definite tendency to a semi-ring porous condition in one species, while the rays are mostly Heterogeneous IIA with some of the less specialized Heterogeneous I. Vessel side walls are predominantly round pitted, and conspicuously marked with tertiary spiral thickenings. Some fibrous elements also show tertiary spirals. Tertiary thickening is found elsewhere in the family in *Torricellia* and to a limited extent in *Helwingia*. Solereder (1908) reports tertiary thickening in *Cornus oblonga* Wall., which was not available for the present study.

The extent of variation in anatomical characters among the species is shown in the following table.

Aucuba chinensis Benth. (Y #21794—Fan Mem. Inst. #0182; NY—*C. Wang 36513*); *A. japonica* Thunb. (Y #14600—*M. Fujioka*; cultiv., auth. collection); *A. himalaica* Hook. f. et Thoms. (NY—*J. D. Hooker*).

	A. chinensis	*A. japonica*	*A. himalaica*
Vessel length			
Max.	1290μ	1192μ	1074μ
Min.	812μ	622μ	720μ
Av.	1085μ	952μ	878μ
Vessel diam.			
Max.	59μ	49μ	37μ
Min.	28μ	31μ	28μ
Av.	39μ	39μ	35μ
Ratio	28:1	25:1	25:1
Perforation			
% Scal. 31 + bars	50	100	100
% Scal. 30 − bars	50	0	0
Av. no. bars	35	56	45

Tribe KALIPHOREAE Trib. nov.

Trees or shrubs with alternate coriaceous leaves. Flowers tetramerous, dioecious, on ebracteate, non-articulate pedicels in small axillary panicles. Ovary 2-celled, a single ovule in each cell. Fruit drupaceous, separable into two 1-seeded nutlets. Wood diffuse porous, tending to semi-ring porous. Vessel elements round in outline, unevenly thick walled, with much reduced, round pits on side walls. Perforations simple porous, the end walls oblique. Rays of type Heterogeneous II A.

Kaliphoreae consists of the monotypic genus *Kaliphora* Hook. f. of Madagascar. Included in Corneae by Wangerin, its removal therefrom is based chiefly upon anatomical characters. Among the Corneae of Wangerin its separable fruit is distinctive as are the elongate, elliptic, basifixed anthers. Anatomically the genus occupies a very advanced position. In the semi-ring porous wood the vessels occur frequently in short radial chains and singly. Vessels are very short, averaging 370μ, comparatively wide, 49μ, giving a length-width ratio of 7.5:1, second lowest for the family. The simple porous vessel element end wall is inclined to the long axis of the vessel at an average angle of 41°, highest for the family. Fibrous elements are almost entirely libriform. The Heterogeneous IIA rays are a mark of advancement found elsewhere in the family as the sole type only in *Torricellia*. The tribe appears to represent the result of an extensive anatomical and morpho-

logical specialization whose point of departure is difficult to locate with reference to other genera of the Corneae of Wangerin, but it appears to be more closely related to *Corokia* than to *Cornus*.

Variation in anatomical characters is shown in the following table.

Kaliphora madagascariensis Hook. f. (P #899—*R. Baron* in 1889).

	K. madagascariensis
Vessel length	
Max.	471μ
Min.	248μ
Av.	370μ
Vessel diam.	
Max.	69μ
Min.	34μ
Av.	49μ
Ratio	7.5:1
Perforation	Porous

Tribe HELWINGIEAE Wangerin

Shrubs with alternate leaves and deciduous branched or hair-like stipules. Flowers small, dioecious, 3–5 merous, the calyx obsolete, in small epiphyllous umbels. Ovary 3- or 4-locular. Fruit drupaceous, separable into 3 or 4 one-seeded cartilaginous or leathery nutlets. Wood diffuse porous with slight tendency to semi-ring porous. Vessel elements angular to rounded in outline, mostly with thin and even walls and scalariform to elongate-elliptic side-wall pits and occasional tertiary spiral thickening. Perforation plates scalariform, mostly few-barred, the end walls steeply inclined. Rays of type Heterogeneous I.

The tribe Helwingieae consists of the genus *Helwingia* Willd. with three species in Japan, China and the Himalayas. Both morphologically and anatomically the tribe displays an interesting assortment of primitive and derived features. The tendency to a reduced but variable number of floral parts, the few-flowered umbellate inflorescence and dioecism are marks of derivation, possibly recent. These gross evidences of relative advancement are accompanied by anatomical features which also suggest a transition to a higher state of specialization. This is noticeable in the slight tendency to semi-ring porosity of the wood, and the occurrence of some unevenly thickened vessel walls which occasionally have tertiary spiral thickenings. Similarly, the scalariform perforations are few-barred, the average for the tribe being 23. Fibrous elements are approximately equally fiber-tracheids and libriform fibers with a few of these septate. However, the multilocular ovary and separable 1-seeded nutlets are clearly primitive, as are such anatomical characters as the scalariform to elongate-elliptic side-wall pits and steeply inclined (average 10°) end walls of vessel elements. Averages for vessel element length and width are 670μ and 32μ respectively. Although the vessel elements are considerably shorter than the average for Cornoideae and for Cornaceae the small diameter gives a length-width ratio of about 21:1. It seems evident that Helwingieae must be regarded as a fundamentally primitive group in Cornoideae which has made moderate advances in a few morphological and anatomical characters.

Variation in anatomical characters among the species is shown in the following table.

Helwingia chinensis Batalin (NY—*Ho-Chang Chow 656*); *H. japonica* Dietr. (NY—*Kanehira 3434*); *H. himalaica* Hook. et Thoms. (NY—*Henry 11992*; US—*Henry 6719.*)

	H. chinensis	*H. japonica*	*H. himalaica*
Vessel length			
Max.	903μ	772μ	917μ
Min.	451μ	537μ	301μ
Av.	729μ	665μ	616μ
Vessel diam.			
Max.	43μ	41μ	32μ
Min.	28μ	31μ	20μ
Av.	36μ	34μ	27μ
Ratio	20:1	19:1	22.5:1
Perforation			
% Scal. 31 + bars	0	0	15
% Scal. 30 − bars	100	100	85
Av. no. bars	20	26	24

Tribe TORRICELLIEAE Wangerin

Small trees with alternate palmately veined, long-petiolate leaves, the petiolar base expanded at junction with stem. Flowers small, dioecious, in long, lax many-flowered panicles. Pistillate flowers apetalous, on bracteolate, articulate pedicels. Ovary 3- or 4-locular. Fruit a 1-seeded drupe. Wood ring porous, the late wood pores in irregular tangential bands of clusters and 2–5 multiples. Vessel elements round in outline, unevenly thick walled, the side walls densely alternate and bordered pitted and mostly with tertiary spirals. Perforations simple porous, the end walls nearly transverse in spring elements. Rays of type Heterogeneous IIA.

The tribe Torricellieae consists of the single genus *Torricellia* DC. with two or three species of tropical or temperate central and eastern Himalayas. Anatomically, the tribe stands well apart from and in advance of other tribes in the subfamily. The ring porosity of the wood is conspicuous and unique. The simple-porous vessel elements are very short and relatively broad, giving a length-width ratio of 5.6:1, the lowest for Cornaceae. Vessel element end walls are inclined to the long axis of the cell at an average angle of 40°, those of the spring wood being almost transverse. Most vessel elements possess a tertiary spiral thickening. Fibrous elements are exclusively libriform, predominantly septate and very short, averaging 855μ. The over-all character of the wood is suggestive of araliaceous affinities. Morphologically, the lax paniculate inflorescence and 3- or 4-locular ovary are relatively primitive. The tribe appears to represent the culmination of a long and rather independent line of evolution in which the more striking advances have been made along anatomical lines.

The following chart shows the extent of anatomical variation.

Torricellia angulata Oliv. (US—*E. H. Wilson 2349, 4611*). *T. angulata* var. *intermedia* (Harms) Hu (NY)—*Petelot 6363*; Y #21773 (as *T. "arguta"* var. *intermedia*)—Fan Mem.

	T. angulata
Vessel length	
Max.	681μ
Min.	268μ
Av.	444μ
Vessel diam.	
Max.	192μ
Min.	31μ
Av.	78μ
Ratio	5.6:1
Perforation	Porous

Tribe GRISELINIEAE Wangerin

Shrubs, trees or scandent epiphytes with alternate sometimes coriaceous leaves. Flowers hermaphrodite or dioecious, 5-merous, the pistillate sometimes apetalous, in simple terminal or axillary racemes, clusters of racemes, or panicles. Ovary 1- or 2- (rarely 3-) locular with single ovule in each locule. Fruit a berry (unknown in *Melanophylla*). Wood diffuse porous with little or no wood parenchyma. Vessel elements rounded angular in outline with thin and even or slightly thickened and uneven walls and elongate-elliptic and round side-wall pits. Perforation scalariform with few bars, or simple porous. Rays of type Heterogeneous I.

The tribe Griselinieae consists of *Griselinia* Forst. with about six species in New Zealand, Chile, and Brazil and *Melanophylla* Bak. with possibly three species confined to Madagascar.

On consideration of general morphological and anatomical characteristics the two genera seem to constitute a satisfactory tribal group whose general position in Cornoideae is relatively primitive.

Griselinia is the less specialized genus of the tribe. Average vessel element length is 1062μ and average width is 55μ, giving a rather high length-width ratio of about 21:1. Perforations are exclusively scalariform with an average of 16 bars per plate, none having in excess of the median 31 bars. With the exception of one of the species studied, the inclination of the end wall to the long axis of the vessel element is somewhat less than 12°. Vessel side-wall pits are predominantly round. Fibrous elements are mostly fiber-tracheids and these are non-septate. In addition to the reduced bar number in perforations, the chief evolutionary advance has been morphological with the development of dioecism and a 1-locular ovary.

Variation in anatomical characters among the species is shown in the following table.

Griselinia littoralis Raoul (NY—*Meebold 4103;* Y #6601); *G. lucida* Forst. (Y #37882); *G. jodinifolia* (Griseb.) Taub. (CNC—*Junge* in 1932; US—*Buchtien* in 1898); *G. racemosa* (Phil.) Taub. var. "hojas acumiana" (US—*Buchtien* in 1898).

	G. littoralis	*G. lucida*	*G. jodinifolia*
Vessel length			
Max.	1441μ	1768μ	982μ
Min.	537μ	1244μ	713μ
Av.	905μ	1447μ	835μ
Vessel diam.			
Max.	82μ	130μ	37μ

	G. litteralis	*G. lucida*	*G. jodinifolia*
Min.	23μ	62μ	23μ
Av.	44μ	90μ	31μ
Ratio	21:1	16:1	26:1
Perforation			
% Scal. 31 + bars	0	0	0
% Scal. 30 − bars	100	100	100
Av. no. bars	19	14	16

Material of *G. racemosa* was too young for vessel measurements, but was in agreement with other species in all other anatomical characters except that number of bars per perforation plate averaged 31.

In contrast to *Griselinia* the flowers of *Melanophylla* are hermaphrodite and the ovary is 2- or 3-locular. Its anatomical position, however, is more advanced. Vessel elements average 759μ in length and 53μ in width. While the average width is not significantly different from that of *Griselinia*, the length-width ratio is markedly advanced, being about 14:1. Perforations of vessel elements are chiefly of two types, scalariform, and simple porous with some intermediate scalariform porous. [cf. Wangerin, 1906, in Engl. Bot. Jahrb. *38*.] The scalariform perforations have an average of 15 bars. Simple porous perforations constitute about 16% of the total. Inclination of vessel element end walls averages 15°. Vessel side-wall pits are chiefly round with some of the elongate-elliptic type. Fibrous elements are about equally fiber-tracheids and libriform fibers, about half the latter being septate.

In view of the striking contrast in evolutionary accent in *Melanophylla* and *Griselinia* it seems clear that their development has been parallel from a more primitive stock derived in its turn from the main cornoidean line.

Variation in anatomical characters are shown in the following table.

Melanophylla alnifolia Bak. (P—*Baron 3240*); *M.* sp. (P#517—*Humblot* in 1883).

	M. alnifolia	*M.* sp.
Vessel length		
Max.	1021μ	753μ
Min.	674μ	425μ
Av.	890μ	626μ
Vessel diam.		
Max.	62μ	57μ
Min.	46μ	46μ
Av.	54μ	51μ
Ratio	16:1	12:1
Perforation		
% Scal. 31 + bars	0	0
% Scal. 30 − bars	82	85
% porous	18	15
Av. no. bars	16	13

CONSIDERATIONS OF PHYLOGENY

From consideration of the facts of morphology and anatomy, it is clear that the family Cornaceae is a fairly homogeneous group, with few discordant ele-

ments, and probably is correctly estimated as the primitive family of the traditional Umbellales. In floral pattern a high degree of constancy has been achieved with constant and complete epigyny, 4 or 5 (very rarely 3 or 6) calyx lobes, petals and stamens, and 1- to 4-celled ovary. Flowers are uniformly small and borne in a series of inflorescence patterns from open paniculate types to condensed and specialized cymes resembling umbels or small capitula. Fruits are drupaceous or rarely baccate, the seed endospermic with small embryo. In anatomical characters of the wood, similarly, a number of important characteristics are constant features of the family. These, along with the constant morphological characteristics emphasize the evident homogeneity. Thus, the diffuse porous wood with sparse and diffuse wood parenchyma, rays of similar heterogeneous types, and vessels with scalariform perforations are, with very rare exceptions, constant for the family.

These facts may be urged in support of a monophyletic origin for the Cornaceae or may indicate merely the attainment of a rather uniform level of evolutionary development by the existent genera. Wangerin's recognition of three subfamilies chiefly on the basis of the relative position of the micropyle of the anatropous ovules permits the division of the family into two groups consisting of Mastixioideae and Curtisioideae in which the micropyle is extrorse, and Cornoideae in which it is introrsely situated. What phylogenetic significance attaches to this characteristic is unknown, but it combines with the development of secretory ducts in *Mastixia* to give Mastixioideae a unique position within the family. It has been suggested by others that *Mastixia* may represent a link between Cornaceae and Araliaceae, or possibly that a *Mastixia*-like form served as a common ancestor of the two families. With the exception of the regularly unilocular ovary, which is doubtless the result of relatively recent reduction, *Mastixia* is clearly very primitive. This is well substantiated by the evaluation of anatomical characteristics. Curtisioideae, although allied with Mastixioideae by the character cited above, is without secretory tissue, and thus appears to stand in an intermediate position between Mastixioideae and Cornoideae. Anatomical data also clearly suggest this. The number of floral parts has been reduced to 4, although the primitive 4-locular ovary has been retained. The subfamily Cornoideae, in its average expression, represents a third and higher degree of specialization. Morphologically, it has attained in some genera a reduction of number of floral parts to 3, the dioecious condition, unilocular ovary, and highly specialized inflorescence patterns. Anatomically, it displays the most highly specialized conditions.

It seems most fruitful to view the three subfamilies as the culminations of three essentially separate lines of evolutionary development which had their origin in some remote, possibly single, ancestral type. Fig. 2, based upon anatomical and morphological data, is intended to express the inter-relationships among the subfamilies, tribes and genera. The range of anatomical variation is approximately indicated by the vertical dimension of the rectangles enclosing generic names. *Mastixia* and *Curtisia* pursued parallel courses, the latter attaining a somewhat more highly specialized condition, anatomically. The developmental line leading

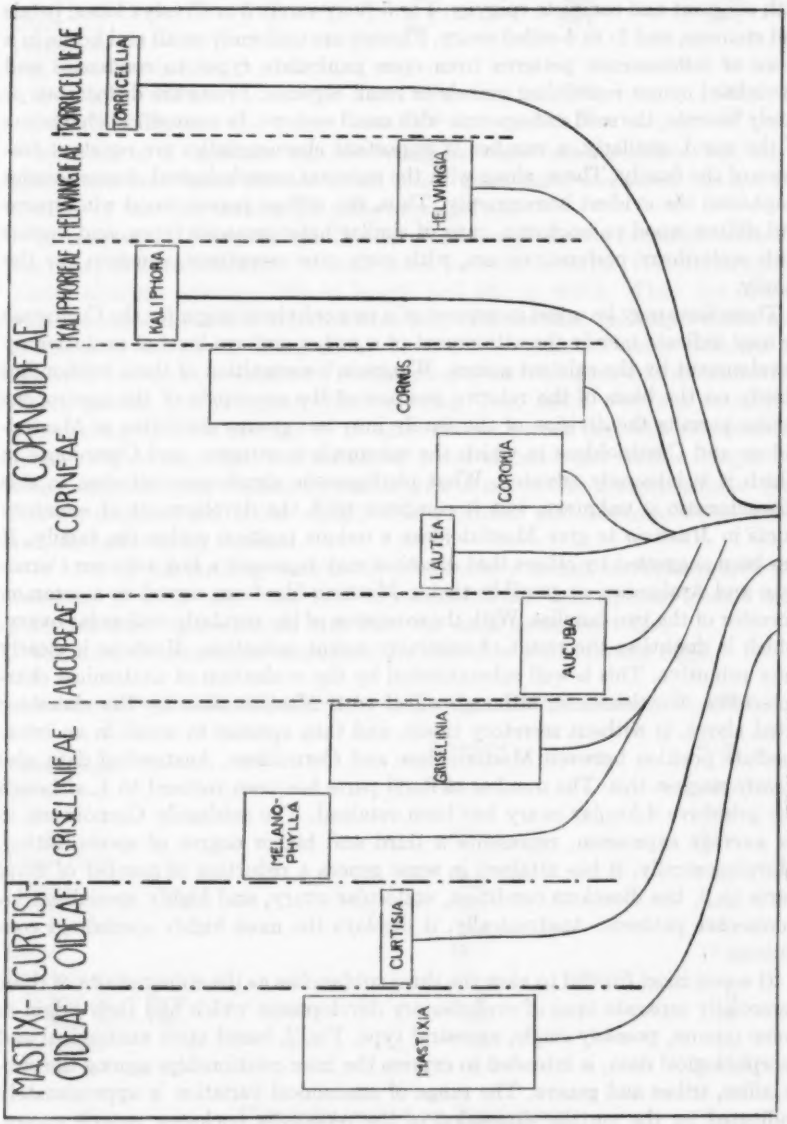

FIG. 2. Phylogenetic relationships among genera and tribes of Cornaceae

to Cornoideae was abruptly divergent from the other two and demonstrated considerable evolutionary vigor as evidenced by the number of its constituent genera. The tribe Corneae, consisting of *Lautea*, *Corokia*, and *Cornus* represents the main trend of the cornoidean line.

Lautea and *Corokia*, although morphologically primitive in the tribe, are anatomically more specialized than some of the species of *Cornus*. Therefore, *Cornus* must have been differentiated from the cornean stem at an early period.

The tribe Aucubeae is regarded as a fundamentally primitive offshoot from the cornoidean line at a point somewhat below the Corneae. Its primitive position rests chiefly upon vessel characteristics, baccate fruit and inflorescence pattern. Spiral tertiary thickening of vessel walls and some fibers, rays of a derived type, and the tendency to semi-ring porous wood are the results of precocious and possibly recent anatomical development. The unilocular ovary, tetramery and dioecism are similarly regarded.

Kaliphora is most closely related to the Corneae. Its long evolutionary history has produced a degree of specialization in all anatomical and some morphological characters, well beyond that attained by the Corneae. It has retained as evidence of its great age, a primitive inflorescence pattern and separable drupaceous fruit.

The tribe Helwingieae, variously considered in and out of Cornaceae by earlier systematists, is conspicuous by virtue of its stipules and epiphyllous inflorescence. The 3- or 4-celled ovary and fruit with 3 or 4 separable nutlets suggest that it may have arisen from the differentiating cornoidean line at about the point of origin of *Kaliphora* but somewhat earlier. Active reduction of flower parts seems to be in progress. The umbellate inflorescence is probably not closely related to the similar pattern in *Cornus*, and the adnation of peduncle to leaf is of little or no phylogenetic significance. The tribe is anatomically predominantly primitive but displays a variety of transitional conditions and advanced features that are quite in keeping with the progressing morphological changes. The stipules of *Helwingia* may be a mark of relationship to Araliaceae.

In anatomical characters *Torricellia* is the most highly specialized genus in Cornaceae. Its lax paniculate inflorescence, pentamerous (though reduction is in progress) and multilocular ovary are primitive characters suggesting a long developmental history. To establish a satisfactory point of departure from the line of the Cornoideae is difficult. The wood structure suggests possible affinity with certain araliaceous genera, and the expanded petiolar bases resemble those of Araliaceae. It seems best to suggest that it originated at a very remote time, pursued a course parallel and close to the cornoidean line and diverged therefrom prior to the differentiation of other cornoidean tribes.

In the tribe Griselinieae *Melanophylla* is considerably more advanced than *Griselinia* in anatomical characters, these advances are, for the most part, extensions of tendencies manifest in the latter. *Melanophylla* has retained certain primitive features of flower structure not shared by *Griselinia* and must, therefore, have arisen at a relatively early period in tribal development. *Griselinia*, meanwhile, has made notable morphological advances, notably in reduction of ovary to one cell.

LITERATURE CITED

BAILEY, I. W., AND W. W. TUPPER. 1918. Size variation in tracheary cells. I. A comparison between the secondary xylems of vascular cryptogams, gymnosperms, and angiosperms. Proc. Amer. Acad. Arts Sci. **54**: 149–204.

BENTHAM, G., AND J. D. HOOKER. 1867. Genera Plantarum. L. Reeve & Co., London, 1862–1883.

BESSEY, C. E. 1915. The phylogeny and taxonomy of angiosperms. Ann. Missouri Bot. Gard. **2**: 109–164.

BROWN, F. B. H. 1926. *Lautea*, a new genus of the Cornaceae. Proc. Hawaiian Acad. Sci. Bernice P. Bishop Museum. Spec. publ. no. 11, p. 26.

———. 1928. Cornaceae and allies in the Marquesas and neighboring islands. Bernice P. Bishop Museum Bull. no. 52.

CHALK, L., AND M. M. CHATTAWAY. 1934. Measuring the length of vessel members. Trop. Woods **40**: 19–26.

COX, HIDEN T. 1948. Studies in the comparative anatomy of the Ericales. I. Ericaceae—subfamily Rhododendroideae. Amer. Midl. Nat. **39**: 220–245.

———. 1948a. Studies in the comparative anatomy of the Ericales. II. Ericaceae—subfamily Arbutoideae. Amer. Midl. Nat. **40**: 493–516.

DANSER, B. H. 1934. The Cornaceae of the Netherlands Indes. Blumea **1**: 46–74.

DARLINGTON, C. D., AND E. K. JANAKI AMMAL. 1945. Chromosome Atlas of Cultivated Plants. George Allen & Unwin. London.

DERMEN, H. 1932. Cytological studies of *Cornus*. Jour. Arn. Arboret. **13**: 410–415.

ENGLER, A. 1930. Saxifragaceae *in* A. Engler and K. Prantl, Die natürlichen Pflanzenfamilien, ed. 2. **18a**: 215.

——— AND L. DIELS. 1936. Syllabus der Pflanzenfamilien. ed. 11.

FROST, F. H. 1930. Specialization in secondary xylem of dicotyledons. I. Origin of vessel. Bot. Gaz. **89**: 67–94.

———. 1930a. Specialization in secondary xylem of dicotyledons. II. Evolution of end wall of vessel segment. Bot. Gaz. **90**: 198–212.

———. 1931. Specialization in secondary xylem of dicotyledons. III. Specialization of lateral wall of vessel segment. Bot. Gaz. **91**: 88–96.

GARRATT, G. A. 1933. Systematic anatomy of the woods of the Myristicaceae. Trop. Woods **35**: 6–48.

———. 1934. Systematic anatomy of the woods of the Monimiaceae. Trop. Woods **39**: 18–44.

GILBERT, S. G. 1940. Evolutionary significance of ring porosity in woody angiosperms. Bot. Gaz. **102**: 105–120.

HARMS, H. 1898. Cornaceae *in* A. Engler and K. Prantl, Die natürlichen Pflanzenfamilien **3**, Abt. 8: 254–255.

HOAR, C. S. 1915. A comparison of the stem anatomy of the cohort Umbelliflorae. Ann. Bot. **29**: 55–65.

HUTCHINSON, J. 1926. The Families of Flowering Plants. I. Dicotyledons. Macmillan & Co. London.

KRIBS, D. A. 1935. Salient lines of structural specialization in the wood rays of dicotyledons. Bot. Gaz. **96**: 547–557.

MUELLER, L. 1864. The Vegetation of the Chatham Islands. Melbourne.

RICKETT, H. W. 1945. Cornales. N. Amer. Fl. **28B**: 297–316.

SOLEREDER, H. 1908. Systematic Anatomy of the Dicotyledons. Trans. L. A. Boodle and F. E. Fritsch. Clarendon Press. Oxford.

TIPPO, O. 1938. Comparative anatomy of the Moraceae and their presumed allies. Bot. Gaz. **100**: 1–99.

WANGERIN, W. 1910. Cornaceae *in* A. Engler, Das Pflanzenreich **4** (229): 1–110.

STUDIES IN THE WOODY ANATOMY OF THE FAMILY NYSSACEAE

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INTRODUCTION

The systematic position of Nyssaceae has been as varied, almost, as the systematists who have considered this problem. This is, at first glance, surprising since the family contains only three genera including from twelve to possibly fifteen species. Only one genus, *Nyssa*, has a wide distribution. This genus is found in eastern North America with perhaps six species, one of which, *N. sylvatica* Marsh., is quite widespread; as it has been reported, recently, in Mexico in an extension of the range along the Gulf coast. The other two genera, *Davidia* and *Camptotheca*, which are generally considered monotypic, are to be found endemic in the eastern border of Tibet, subtropic China and into the monsoon belt. This range is shared with the remaining species of *Nyssa*. The family members are, so far as is known, trees of relatively great height, with the exception of *N. acuminata* Small and *N. ursina* Small, both native to Florida and described by him (1933) as shrubs less then three meters in height.

The floral parts are highly variable in the family. The family may be considered as polygamo-dioecious, or possibly dioecious in some instances. The pistillate flower of *Camptotheca* is still imperfectly known. The carpel number varies from one to ten. The floral parts seem to be basically pentamerous with wide variation from this number. The perianth varies and is frequently reduced to a weakly toothed fringe of scales varying in number. The fruit is drupaceous throughout and one- to five-seeded.

The variability of the family characters is reflected in the placement of the family and the genera. Bentham and Hooker (1883), for example, place *Nyssa* in Cornaceae as does Harms (1898). Engler (1909) places Nyssaceae in the Myrtales between Rhizophoraceae and Alangiaceae, while Baillon (1877) places *Nyssa* in Combretaceae. Endlicher (1838) removed *Nyssa* from Cornaceae and recognized the family Nyssaceae which he places near the Santalaceae. Wangerin (1910) maintains the family Nyssaceae and says in reference to its placement that the family was separated from the Cornaceae on the basis of diplostemony and the presence of a double integument about the ovule. Wangerin states that while *Nyssa* and *Camptotheca* are apparently closely related, *Davidia* seems hardly closer to them than it does to Cornaceae but that it is given provisional accommodation within the family since it does not seem to fit any better into any other family.

Data of an anatomical nature have been meagre and of a very general sort. Solereder (1908) treats the three genera in his consideration of Cornaceae but makes no specific reference that is applicable. Much of the information he gives

is based on the work of Wangerin, and since Wangerin has made the most exhaustive study of the family in general, his treatment in Das Pflanzenreich was utilized considerably by the writer in the prosecution of this study. Anatomical evidence in application to problems in systematics has been utilized by Tippo in his studies of Moraceae (1938) and by others. It is the purpose of the present study to arrive at some concept of the intergeneric relationships of Nyssaceae preliminary to a possible subsequent revaluation of the systematic position of Nyssaceae among its presumed allies.

MATERIALS AND METHODS

Collections of stems evidencing both primary and secondary growth were obtained from the University of North Carolina Herbarium (CNC), the Herbarium of the New York Botanical Garden (NY), and The United States National Herbarium (US). In addition, fresh material was collected by the writer (auth.) wherever possible and blocks of secondary xylem obtained from the Yale School of Forestry (Y) were studied.

Sections and macerations were made of secondary wood. Tissue was softened with glycerine, alcohol, and water mixture and sectioned at 12 microns in radial, tangential, and cross sections on the sliding microtome, stained with safranin and mounted in Euparal.

The maceration of tissues was effected by a modification of Jeffrey's technique. The tissue was shaved into small chips and soaked in a 1% Tergitol solution for 24 hours after which it was left in Jeffrey's maceration fluid diluted to 50% with distilled water and placed in a warming oven for four to twelve hours. This treatment separated the tissues thoroughly without causing the disintegration of cells that sometimes occurs when the maceration fluid of full strength is used. The maceration fluid was quickly removed with water in repeated washings and the material concentrated by centrifugation. When the fluid containing the macerated tissue no longer gave an acid-positive litmus reaction, it was assumed that all maceration fluid was removed and the macerated tissues were stored in vials of glycerin-alcohol-water with about one drop of safranin per cubic centimeter of solution until required for observation.

The traditional basic dicta for the comparative study of secondary wood elements were considered with certain modification in the observation of this material. These dicta, derived chiefly from the work of Gilbert, Frost, Kribs and others, have been fully discussed by Cox (1948).

The cross sections of wood blocks were used to obtain the type of porosity, the shape of the vessel in cross-section and the wood parenchyma distribution. Tangential sections were used to determine the medullary ray type and the inclination of the end wall of the vessel to the side wall. Radial sections were used to check the medullary ray determinations and to study intercellular pitting. Semi-permanent mounts were made of macerated material and the following data were collected therefrom. The scalariformity, number of bars per plate, the maximum diameter, diameter at midpoint, vessel length, degree of bar borders, and side-wall pitting was determined for each vessel and recorded

for the average. The fiber length and type were determined from macerated material also.

The length-width ratio of the vessel cited for the species was computed by determining the average width and length of the specimens and computing the average width and length of the species from these figures. The ratio was then obtained by dividing the average species length by the average species width. The ratio characteristic is an application of the data of Cox (1948). If two compared forms are equal in average vessel lengths but with a different ratio in average vessel length to width, all other vessel structures being equivalent, the form with the lower ratio is considered advanced. The range of length to width ratios for the family is from 7:1 to 35:1, a considerable range.

A wide range in the number of bars in the perforation plate was found. The averages varied from 25 to 75 for genera within the family. An arbitrary mid-point of 52 was set as a line of separation between the primitive many-barred and the advanced few-barred condition within the family limit.

The end-wall angle was found to range between 10° and 25°. The arbitrary mid-point of 16° was set up as a line of separation between primitive narrow-angled and the advanced (or derived) wide-angled end walls, within the family limits, and the figures are so indicated in Table 3.

The average was derived from forty to fifty units for the computations of each specimen and the minimum and maximum figures for each were also recorded. The units were remarkably uniform within any particular specimen. Since, with very few exceptions, there were at least two specimens representing each species (and sometimes more), actually between eighty to a hundred units were measured for the average figure utilized in the individual species and it is this final average that is set down in Table 3.

The general condition of Nyssaceae as indicated by wood characters appears to be primitive. The family was found to be consistent and uniform in the following characters:

1) The absence of ring porosity.
2) The presence of scalariform perforation.
3) Opposite side-wall pitting with an occasional scalariform lateral.
4) Absence of tertiary thickening of vessel walls.
5) Small clusters of vessels at most.
6) Diffuse and sparse xylem parenchyma.
7) Absence of Homogeneous medullary ray types.
8) Inclination of end wall of less than 26°.

It is apparent that with minor variation, these consistencies are generally primitive in nature. It is necessary, then, to consider the variation in other vital characteristics. The number of bars in the perforation plate, the diameter and length of vessel segment and their ratio, and other variations were studied carefully in order to ascertain the relative primitiveness of the genera and the species, from an anatomical viewpoint.

Evaluation of the species in anatomical terms was then compared with the morphological data and characteristics. This morphological information was

obtained from the various descriptions of the family members available and evaluated according to the morphological characteristics set forth in the precepts of morphological evolution as laid down by Hutchinson (1926). Those precepts particularly applicable to the present case may be summarized as follows:

1) Bisexual flowers precede unisexual flowers.
2) Polycarpy precedes oligocarpy.
3) Many stamens are more primitive than few stamens.

The precepts are of a general nature and external conditions may cause variation that is not of evolutionary significance. A comparison of the members of the family was attempted with the knowledge that there would be individual variation, as not all elements change at the same rate within the phylogeny of a group. An effort is made to correlate the anatomical details of Nyssaceae with the morphological data. With such an integration it is believed that a clearer picture of inter-relationships within the family may be obtained. The anatomical evidence is considered to be of a confirmatory nature wherever morphological evidence is adequate and in no case is it attempted to supplant morphological evidence.

DISCUSSION

Nyssaceae is a small but widely varied family. The family consists of trees (only two species are described as shrubs) and is to be found in eastern United States, along the Gulf coast and the temperate and sub-tropical area of Asia and the adjacent islands. No other areas of distribution are known with the possible exception of a generally discredited species described as growing in New Guinea (*Nyssa Hollrungii* Schum.). The flowers are regular, pentamerous, hypogynous, bisexual or unisexual, polygamo-dioecious or dioecious, with stamens as many or twice as many as sepals or petals or fewer, rarely more. Petals and sepals are frequently reduced and occasionally missing. The anthers are introrse, opening by slits. The gynoecium is one-carpellate with a one-celled ovary containing one ovule, to ten-carpellate, with a corresponding number of cells, each with one ovule. The ovules are pendulous from the top of the cell. Wangerin and others have stated that two integuments are present but the writer was unable to demonstrate the presence of more than one integument in the fruits of *Nyssa* species available, even when the fruits were very young. The style is simple and stigmatic on the inner surface or with as many branches as carpels. A disk is frequently to be found on the ovary. The fruit is drupaceous.

Anatomically, the family is consistent in 1) being diffuse porous, 2) unevenness of vessel walls, 3) vessel end wall with an angle of less than 26°, 4) scalariform bars in perforation plates averaging seventy-five or less per plate, 5) elongate-elliptic side-wall pits with rare lateral scalariform ones, 6) absence of tertiary thickening (rare tertiary thickening at the very tips of vessel segments as indicated by Record and Hess, 1943, p. 411, in *Nyssa*, was not observed by the writer), 7) absence of septate fibers. Other anatomical features which are

present but not common to the various family members will be considered in a diagnostic discussion of the various species and genera.

The three genera will be treated separately in what appears to be the correct phylogenetic sequence. There is some confusion in nomenclature of the species of this family. Specimens were occasionally received under synonymous names and in such cases the synonym is included in parenthesis before the specimen listing.

Sub-Family DAVIDIOIDEAE Harms

Inflorescence inclosed in two involucres. Stamens 1–7 on staminate and pistillate flowers according to Wangerin (1910) and Rehder (1930), but Johnson (1931) claims that the staminate flower has only one stamen per flower. There is a general reduction of petals and sepals to obscurity. The bisexual flower is to one side of the common receptacle of the inflorescence with a 6–10-carpellate gynoecium with inferior ovary supporting a style bearing radiate stigma branches equal in number to the number of carpels. The fruit is a drupaceous berry. The wood is diffuse-porous with vessels oval-angular in outline, thick and uneven in wall, with an average diameter at the mid-point of 44 microns, a minimum of 39 microns and a maximum of 65 microns, and an over-all average length of 1341 microns with a minimum of 1172 microns and a maximum figure of 1572 microns, and length to width ratio of 30:1. The angle of the end wall to the side wall is 12° and the perforation plate has an average of seventy-five bars per plate. The fibrous-elements are largely fiber-tracheids and the medullary rays are Heterogeneous I.

DAVIDIA Baillon

D. involucrata Baill.: *R. E. Ching 5214* (NY); *Y. Tang* (Y 29792). *D. involucrata* var. *Vilmoriniana* Wang.: *G. Forrest 26541* (NY); *J. F. Rock 10238* (US 1511149); *J. F. Rock* (US 1511150); Cultiv. at Ann Arbor 5159 (Y 29360); Cultiv. at Kew (Y 12683).

There is only one species, *D. involucrata* Baillon (Adansonia **10**: 114, 1871) for which the above description will suffice. This species is to be found in Tibet and central China. There is one good variety, *D. involucrata* var. *Vilmoriniana* (Dode) Wangerin, which varies only in the glabrous quality of the mature foliage. This variety is to be found in subtropic central China.

This sub-family is, in its floral characteristics, primitive, having the only considerable number of carpels in the family and the most nearly perfect flowers. This primitive position is well borne out anatomically. Particularly significant is the medullary ray type, there being no other member of the family having the primitive Heterogeneous type I ray. The length of the vessel element is the longest of the family and the ratio of length to diameter in the vessel, is highest in the family. The end-wall angle is the narrowest of the family and the perforations of the vessel plate are greatest in number in the entire family, viz. seventy-five. The only anatomical precocity of the genus is evidenced in a

tendency to oval outline of vessels, uneven walls, and occasional libriform fibers. The findings may be studied in detail in Table 3.

Sub-family NYSSOIDEAE Harms

Polygamo-dioecious or dioecious. Staminate flowers with five sepals and five alternately arranged petals variably reduced. Stamens are ten in number with apparent diplostemony. No ovarian rudiments are to be found as a rule in the staminate flower. The pistillate flower is hermaphroditic, with varying abortion of the androecium. The ovary is inferior with one to two cells, maturing into a drupaceous fruit. Although the occasional finding of two-seeded fruit in *Nyssa* is doubted by Wangerin, this writer has discovered that to be the case in infrequent occurrence. The wood is diffuse porous with thick or thin uneven vessels angular to oval-angular in outline with end-wall angle from 11° to 25°. Vessel perforation plates are scalariform with a range of specific average of bar number from 25 to 59. Tertiary thickening is absent. The medullary rays are type II A or B Heterogeneous.

NYSSA L.

Polygamo-dioecious with staminate flowers numerous, carpellate flowers solitary or in clusters of two or three. The perianth is occasionally reduced or partially absent with a rudimentary gynoecium rarely found in staminate flowers. The stamens are in two circles inserted under a disk, with thin elongate filaments and introrse elliptic-round anthers opening by a long split. The writer has discovered that the five to ten stamens of the hermaphroditic flower occasionally bear functional pollen grains. The hermaphroditic flower has five sepals and five alternate petals with a unicarpellate pistil and a one-celled ovary crowned with a disk. The fruit is drupaceous with a hard seed that has ridges varying from rounded to winged. On the basis of these ridges and their variations, Coulter separates the genus into two groups (1890). Wangerin (1910) divides the genus roughly into the same groups but on the basis of the inflorescence type of the male flower, and Small (1933) divides the genus into two similar groups, largely on the basis of the type of the female inflorescence. The genus varies anatomically. The wood is diffuse-porous with vessels that are angular to oval in outline, thick- or thin-walled and consistently uneven in cross section. The ratio of vessel dimensions varies from 7:1 to 35:1, and the angle of the end wall to the side wall varies from 11° to 21°. The perforation plate is consistently scalariform with the number of bars varying from 26 to 59. The fibers are occasionally libriform and the medullary ray type varies from Heterogeneous II A to Heterogeneous II B.

Of the specimens obtained, seven possible species are considered. Synonyms are given in parenthesis in the treatment of specimens when they were received under those synonymous names. Many described species are not recognized at present, and three species which are recognized as valid according to Index Kewensis (Vol. II and supplements 1885–1940), *N. arborea* Koord (1912). *N. megacarpa* Parker (1927), and *N. Hollrungii* Schum. (1912), were not available

to the writer. *N. Hollrungii* is considered dubious by Wangerin on the basis of the absence of endosperm, and it is now believed to be in Alangiaceae.

Wangerin placed the members of this genus in two sections, according to the inflorescence of the male flower. These sections he called Pedicellatae and Capitatae, respectively, following Harms in this classification. An anatomical comparison was attempted between the various members following Wangerin's morphological classification. Five species (*N. aquatica* L., *N. biflora* (Walter) Sargent, *N. sylvatica* Marsh., *N. sinensis* Oliver, and *N. ursina* Small) were found to meet the morphological requirements of the Pedicellatae.

PEDICELLATAE Harms

Anatomically, *N. ursina*, *N. sylvatica*, and *N. biflora* have the slightly more advanced medullary ray type Heterogeneous II B as opposed to Heterogeneous II A in the remaining two species. All in all, anatomical indications are that *N. sinensis* with Heterogeneous type II A rays, angular vessels with low-angled end walls, above the average number of bars and fiber-tracheids, is the most primitive of the section. In no case does this species have an individual advanced anatomical feature, but it does have a primitive group of characteristics unequalled in the section. *N. sylvatica* seems to be the most primitive of the American species in this section with *N. aquatica* the most advanced of the section from an anatomical standpoint, for it has only one primitive feature that is not shared by the entire family, medullary ray type Heterogeneous II A, and a number of relatively advanced characteristics larger than any other species of this section. (See Table 3.)

The individual species of the Pedicellatae may be described as follows:

Nyssa sinensis Oliver

The inflorescence is umbel-like tending towards a shortened raceme. Staminate flowers have minute calyx lobes, narrow petals, and five to ten stamens inserted on a disk. Pistillate flowers have a minute bract, an inferior ovary and a 2–3 mm.-long style. The fruit is drupaceous. Diffuse wood with fiber-tracheids and Heterogeneous type II A medullary rays is present. The vessels are angular to oval-angular in outline with thin but uneven walls, have an average diameter at the mid-point of 91 microns with a minimum diameter of 72 microns and a maximum diameter of 108 microns and an average length of 1014 microns with a minimum length of 917 microns and a maximum length of 1382 microns. The length to width ratio is 11:1. The end-wall angle is 13°, and the perforation plate bears an average 53 bars.

Nyssa sylvatica Marsh

Staminate flowers are in five-to twelve-flowered racemes with calyx lobes reduced to teeth, have five petals and stamens equivalent in number to that of the perianth lobes. There is a rudimentary style occasionally in the depressed central disk. Pistillate flowers are sessile in a head and usually three in number. The ovary is inferior. In the pistillate flower, which is supported by two basal

bracts covered with hair, there are approximately five sepals and no petals and five to ten rarely fertile stamens. The fruit is a drupe. The wood is diffuse-porous with fiber-tracheids and medullary rays of type II B with vessels of angular outline, thin but uneven walls, an average over-all length of 1309 microns with a minimum length of 1033 microns and a maximum length of 1544 microns and an average diameter at the mid-point of 67 microns with a minimum diameter of 45 microns and a maximum diameter of 120 microns and a length to width ratio of 19:1. The end wall angle is 11° and the perforation plate averages 52 bars.

Nyssa biflora (Walter) Sargent

This species varies morphologically from *N. sylvatica* only in the leaf form, which is spatulate as opposed to oval in *N. sylvatica*, and in the more pronounced ridges of the stone. The female flowers are borne in pairs rather than in threes. The range of *N. biflora* is distinctive, being the coastal swamp area of southeastern United States. Anatomically, it differs from *N. sylvatica* very little. Whereas the average vessel length of *N. sylvatica* is 1309 microns, that of *N. biflora* is 934 microns. *N. sylvatica* has an average diameter at the mid-point of the vessel of 67 microns while *N. biflora* has an average diameter of 46 microns. The minimum and maximum figures for *N. biflora* are: diameter, 45 microns and 85 microns; and length, 831 microns and 1260 microns. Thus the length to width ratio of *N. biflora* is 20:1 as opposed to 19:1 for *N. sylvatica*. The end-wall angle is 14° compared to 11° in *N. sylvatica* and the number of bars on the perforation plate average 59 as against 52 for *N. sylvatica*.

Nyssa ursina Small

This is a shrub with very numerous leaves and flowers and later clusters of globular drupes. The ratio of vessel length to width was 35:1, the highest ratio of any species in the family. Otherwise no significant data were to be derived from the inadequate specimen available. (See Table 1.)

Nyssa aquatica L. (*N. uniflora* Wang.)

The species has very large leaves (9–30 cm.) with a purple-blue drupe that contains a sharp-ridged stone. The pistillate flower is borne singly on a short pedicel. The wood contains Heterogeneous II A medullary rays. Vessels are oval in outline, with thick uneven walls, average diameter at mid-point of 75 microns, minimum diameter of 59 microns and a maximum of 110 microns, and average length of 998 microns, minimum length of 779 microns and a maximum length of 1226 microns and a ratio of 14:1 in length to width. The end-wall angle is 21° and the perforation plate bears an average of only 34 bars. The fibers are occasionally libriform.

The following specimens were studied.
N. sinensis Oliver: *H. H. Hu 043* Fan Mem. Inst. (Y 21459). *N. sylvatica* Marsh.: Cultiv. Ann. Arbor 220a–1 (Y 19479); Author's collections. *N. biflora* Walt.: *J. L. Stearn* (Y 40120); *H. A. Burlage* (CNC 12037); *H. A. Burlage* (CNC

10332); *Ashe* (CNC) (*multiflora*). *N. ursina* Small: *Ashe* (CNC). *N. aquatica* L.: *Millspaugh* (Y 11730); *US* (Y 39419); *H. A. Burlage* (CNC 23652).

CAPITATAE Harms

The Capitatae are those species with the male inflorescences capitate, a condition considered higher than that characterizing the Pedicellatae. The section is represented by three good species: *N. javanica* (Blume) Wangerin (*N. sessiliflora* Hook. and Thomps.), *N. ogeche* Marsh, and *N. acuminata* Small. *N. acuminata* was not available for study.

TABLE 1

Anatomical characteristics of Pedicellatae

	N. SINENSIS	N. SYLVATICA	N. BIFLORA	N. URSINA	N. AQUATICA
Medullary rays Hetero.					
II	A	B	B	B	A
Vessel outline	Oval	Angular	Oval	Angular	Oval
Wall	Thin	Thick	Thick	Thin	Thick
Diam. at mid-point					
Min.	72	45	45	—	59
Ave.	91	67	46	—	75
Max.	108	120	85	—	110
Length					
Min.	917	1033	831	—	779
Ave.	1014	1309	934	—	908
Max.	1382	1544	1260	—	1226
Ratio	11:1	19:1	20:1	—	14:1
End-wall angle	13°	11°	14°	16°	21°
Ave. no. of bars	53	52	59	—	34
Fiber type					
Tracheid	x	x	x	—	x
Libriform		x	x	—	x

Nyssa javanica (Blume) Wangerin

The staminate flowers have irregular calyx lobes usually five in number with five alternate obovate petals and ten stamens in two series. The pistillate flower has the ovary surmounted by a disk and has a simple style. The medullary rays are of Heterogeneous II A type and the vessels are oval in outline, thick and uneven in wall and with a diameter at the mid-point averaging 156 microns with a minimum figure of 115 microns and a maximum figure of 190 microns. The average length for the vessel is 1219 microns with a minimum length of 1101 microns and a maximum length of 1919 microns, giving a length to width ratio of 9:1. The angle of the end wall is 19° and the perforation plate bears an average of 48 bars. The fibers are occasionally libriform.

Nyssa ogeche Marsh

The staminate flowers are sessile in well developed heads. The calyx is very small and reduced. Four to five petals are present and eight to ten stamens in

two series with elongated filaments and elliptical anthers. The pistillate flowers are hermaphroditic, solitary, and subtended by stipitate bracts. The calyx lobes are much reduced and the five petals are small. Five to ten stamens are inserted in a conspicuous disk. The style is very long and incurved. The fruit is a large, red drupe with widely winged seed. The species is characterized anatomically by Heterogeneous II B medullary rays, vessels oval in outline with thin and uneven walls, a minimum diameter at the mid-point of 36 microns, an average figure of 49 microns and a maximum diameter of 68 microns and a minimum length of 697, average length of 802, and a maximum length of 1120 microns, resulting in a 10:1 length to width ratio. The end-wall angle is 19°. Average number of bars in perforation plate is 26 and libriform fibers are frequent.

TABLE 2

Anatomical characteristics of Capitatae

	N. JAVANICA	N. OGECHE
Medullary rays Hetero. II	A	B
Vessel outline	Oval	Oval
Wall	Thin	Thin
Diam. at mid-point		
Min.	115	36
Ave.	156	49
Max.	190	68
Length		
Min.	1101	697
Ave.	1219	802
Max.	1919	1120
Ratio	8:1	10:1
End-wall angle	19°	19°
Ave. no. of bars	48	26
Fiber type		
Tracheid	x	x
Libriform	x	x

The following specimens of the Capitatae were studied.

N. javanica (Blume) Wangerin: *R. C. Ching S 241* (NY); *Chun and Tsu 44231* (US 1675267); *C. Van de Koppel 3553* (Y 15457); *H. Janssonius 2377a* (Y 31024) (*N. sessiliflora*). *N. ogeche* Marsh: *J. L. Stearns 013* (Y 40124); *Ashe* (CNC 1353); *leClair* (CNC); Author's collections.

CAMPTOTHECA Decne.

There is only one species, *C. acuminata* Decne. Dode (1908) describes a new species, *C. yunnanensis*, but Wangerin makes no mention of it and it is not considered by the writer since it agrees in all significant details with *C. acuminata*. A specimen in the New York Botanical Garden herbarium labelled *C. yunnanensis* appears to be merely an immature specimen of *C. acuminata*. The genus then is considered monotypic and has the following characteristics: The flowers are

polygamodioecious. The calyx is five-toothed and there are five imbricate petals with ten stamens in two series, inserted about a disk, with quadilocular anthers dehiscing introrsely. The pollen is tri-pored. The inferior short ovary is compressed. It is a rudiment in the male flower. The style is two-lobed, (very short and immersed in a disk in male flower) and Wangerin states that in spite of this there is only one locule and one seed in the fruit (Pfl. reich, IV 220A, p. 17). The wood is diffuse-porous with medullary rays of Heterogeneous type II A and fiber-tracheids, with vessels that are oval in outline with thin and uneven walls. The vessels have an average mid-point diameter of 58 microns, minimum of 50 and a maximum of 75, and an average length of 894 microns with a minimum length of 817 microns and a maximum length of 931 microns, resulting in a length to width ratio of 16:1. The vessel end wall has an average angle of 25° to the side wall and only 25 bars average per perforation plate.

These characteristics are in general advanced, and the genus is more advanced than a considerable number of the species of *Nyssa*, in most characteristics. In such a significant characteristic as the relative number of bars per perforation plate, *Camptotheca* boasts the lowest number of the entire family. It is believed logical to consider this genus as the most advanced on the above mentioned grounds. The genus appears closely related to *Nyssa* and it seems possible that the two genera may share a common ancestor.

The following specimens of *Camptotheca* were studied. *C. acuminata* Decne.: *R. C. Ching 5241* (NY); *Y. Tsiang 6286* (US 1575042); *H. H. Hu* Fan Mem. Inst. 048 (Y 21463).

CONCLUDING REMARKS

The foregoing discussion is an attempt to shed some light on the relative phylogenetic positions of the genera and species of Nyssaceae through a correlative comparison of the anatomical and morphological characteristics. It has been indicated that *Davidia* is the most primitive genus of the family and that *Camptotheca* is the most advanced, from a morphological point of view, with *Nyssa* intermediate. Anatomical characteristics, in this case, bear out the morphological suppositions with remarkably few exceptions or variations.

Of the intermediate genus, *Nyssa*, the species available were found to fall into two groups or sections, according to Wangerin. Of these two sections, the Pedicellatae is considered more primitive since the second section, the Capitatae, is characterized by an advanced feature, viz., the capitate inflorescence. The anatomical evidence does not dispute this grouping.

The consideration of the individual species of the groups anatomically as well as morphologically indicate that the most primitive species of the genus is probably *N. sinensis* with *N. sylvatica*, *N. biflora*, *N. ursina*, and *N. aquatica* following in the Pedicellatae and *N. javanica* being followed by *N. ogeche* in the more advanced Capitatae.

Since the advanced species are to be found in North America, it is suggested that the family had its origin in eastern Asia, perhaps in Central China and that the dispersal has been to the west as the family developed, with the highly de-

veloped *N. javanica* and *Camptotheca* being found in Asia as the present result of a long line of geographically stationary evolution.

It seems necessary to evaluate the findings derived from this research, particularly as it relates to *Nyssa*, the most diverse and numerous group in the family. *N. sinensis* is the most primitive member of the genus but barely more so than the geographically distant *N. sylvatica*. The indication of possibly nyssoid fossil remains in Tertiary deposits in Europe opens speculation as to the migration of a *Nyssa*-form similar to *N. sylvatica* from the point of origin to the present location of *N. sylvatica* in the wide area of eastern U. S. *N. sylvatica* is discovered to be very close to *N. sinensis* in all anatomical and morphological features. It

TABLE 3

Summary of the anatomical features of the Nyssaceae

	MEDULLARY RAY TYPE			VESSEL OUTLINE	VESSEL WALL		VES. DIAM. AT MIDPOINT	VES. LENGTH	VES. RATIO	VES. END WALL ANGLE		PERF. BARS		FIBER TYPE	
	Het. I	IIA	IIB		Thin	Thick				−16°	+16°	+32	−32	Fib.-tracheid	Libriform
Davidioideae															
Davidia involucrata	x			Oval		x	42	1541	30:1	10°		75		x	x
Davidia involucrata var. Vilmoriniana	x			Oval		x	46	1141	25:1	15°		75		x	
Sub-family average	x			Oval		x	44	1341	28:1	12°		75		x	x
Nyssoideae															
Nyssa Pedicellatae		x	x	Oval-ang.	x		55	1086	20:1	14°		50		x	x
Nyssa Capitatae		x	x	Oval-ang.		x	112	959	8:1		19°	40		x	x
Generic average		x	x	Oval-ang.		x	83	1022	14:1		17°	45		x	x
Camptotheca acuminata		x	x	Oval-ang.	x		58	894	16:1		25°	25		x	
Sub-family average		x	x	Oval-ang.	x		70	958	15:1		21°	35		x	x
Family average	x	x	x	Oval-ang.	x	x	57	1149	20:1	16°	16°	52	52	x	x

is, of course, possible that their development has been parallel rather than that *N. sylvatica* is derived from, or is only a modified form of *N. sinensis* that has migrated. Let us consider, however, the other generic elements that are in geographic approximation.

N. biflora, which grows in a limited portion of the range of *N. sylvatica*, varies very little anatomically from *N. sylvatica*. Morphologically, the variance is chiefly a matter of possible minor modification. The pistillate flowers are in a group of two rather than three, the leaf is spatulate instead of oval and the ridges of the fruit stone are more pronounced. It is suggested that *N. biflora* was derived very recently from *N. sylvatica* considering the closeness of even the superficial morphological features. *N. ursina*, a shrub growing in a small part of the range of *N. biflora* in Florida, seems to continue trends begun in *N. biflora*.

The small leaves of *N. biflora* have become even smaller, the ellipsoid, sometimes rounded drupes of *N. biflora* have become globular, the pistillate flowers are still two or more in number. Anatomically, *N. ursina* lacks characterization because of inadequate material but the end-wall angle is 16°, higher than either *N. sylvatica* or *N. biflora*. It is suggested that on the basis of the evidence at hand, *N. ursina* seems to be derived from *N. sylvatica* through *N. biflora*. *N. aquatica* seems to diverge from *N. biflora* and *N. ursina* but has qualities in common with *N. sylvatica*. The pistillate flower is borne singly on a long pedicel. The fruit is larger than that of *N. sylvatica* while the fruit of *N. biflora* and *N. ursina* is smaller. They are divergent in many other features. The drupe of *N. aquatica* is purple rather than blue-black and the stone of the fruit is very sharply ridged. Anatomically it is more advanced than the lowest number of the other three species. It has an end-wall angle of 21° as against 11°, 14°, and 16° respectively in the other species. It is suggested then, that *N. aquatica* is derived in a straight line from *N. sylvatica* while *N. biflora* and *N. ursina* developed as an offshoot in the recent geologic past. *N. sylvatica* is isolated from its parent, *N. sinensis* by a climatic and geographic gap.

The nearest relative to *N. javanica*, geographically, is *N. sinensis* from which it varies morphologically only in greater size of parts and the presence of a capitate male inflorescence. Anatomically the variation is in a 8:1 length to width ratio as opposed to a 11:1 ratio in *N. sinensis*, an end-wall angle of 19° as opposed to one of 13° and 48 bars per perforation plate as opposed to 53. These variations are not tremendous but indicate a possible derivation.

What about the relationships between *N. javanica* and the other species which shares the section that Wangerin designated Capitatae? A number of morphological differences between *N. javanica* and *N. ogeche* should be pointed out. There are numerous pistillate flowers in the inflorescence of *N. javanica*, while they are borne singly in *N. ogeche*. *N. ogeche* has an elongate style while that of *N. javanica* is abbreviated. The seed of *N. ogeche* is winged while that of *N. javanica* is hardly ridged. The color of the fruit of *N. ogeche* is red while that of *N. javanica* is dark blue-black. *N. ogeche* has Heterogeneous II B rays while those of *N. javanica* are Heterogeneous II A. *N. ogeche* has 22 fewer bars per perforation plate than *N. javanica*. *N. javanica* has only 5 fewer bars, on the other hand, than *N. sinensis* and is otherwise very close, anatomically and morphologically. It is suggested then, that *N. javanica* is derived from *N. sinensis* as an offshoot of relatively advanced nature and that by evolutionary development has reached a level equal to that of *N. ogeche*.

N. ogeche seems to have been derived from *N. aquatica*. There is no large variation anatomically. The only significant difference is possibly of a derivative nature as *N. ogeche* has Heterogeneous II B rays and 26 bars per perforation plate as opposed to 34 bars in *N. aquatica* whose rays are Heterogeneous II A. The fruit of *N. aquatica* is purple and has sharply ridged stones, while that of *N. ogeche* is red and has winged stones. *N. ogeche* and *N. aquatica* have fruit very close in size and they both develop from pistillate flowers that are solitary, while the leaves of the species are the two largest in the genus. It is suggested,

therefore, that the coincidence of the capitate form of male inflorescence in *N. javanica* and *N. ogeche* does not justify the grouping of the two together as a section, this condition having been independently developed, and that the designation of the sections as such by Wangerin is artificial rather than natural.

Camptotheca, the genus which is considered the most advanced in the family,

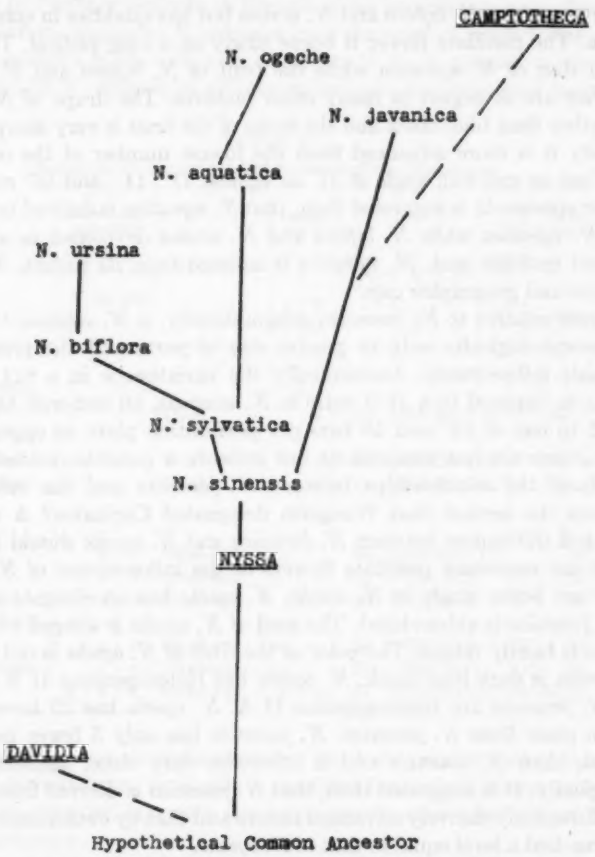

FIG. 1. Suggested phylogenetic relationships in Nyssaceae

has certain qualities intermediate between *N. sinensis* and *N. javanica* and other qualities which are more advanced than either. The leaves of *Camptotheca* are the largest of the entire family, up to 75 cm. in length of blade. The male and female inflorescences are both capitate, an advanced feature. The fruit is in a cluster greater than that of *N. javanica* and becomes dry upon ripening. The anatomy is quite similar to that of *N. sinensis* but varies in having a length to

width ratio greater than that of *N. sinensis* and *N. javanica* (16:1) but a greater end-wall angle (25°), the largest in the family, and also the smallest number of bars per perforation plate, viz. 25. It is therefore suggested that *Camptotheca* arose somewhere on the branch of the phylogenetic line that comes from *N. sinensis* and terminates in *N. javanica*, that it is, perhaps, closer to *N. javanica* in point of origin than to *N. sinensis* and that it has developed to its present high point in geographic proximity to the parent, *N. sinensis*. The other published species, *C. yunnanensis* Dode (1908) appears to be at most a variety since it is described as varying from *C. acuminata* only in having a lighter brown fruit and a slightly variable leaf size. The range is identical with that of *C. acuminata*.

The evidence presented by the present research agrees with the suggestion by Wangerin and others that *Davidia* may be only remotely (if at all) related to the sub-family Nyssoideae. The remoteness of *Davidia*, morphologically and anatomically, is so complete as to make possible the conjecture that development within the family has been polyphyletic. A hypothetical common ancestor of the family as it now stands must have been remote if it existed. It must have been characterized by a height of 40 meters or more, was possibly polygamo-monoecious, with 5–10 stamens in both staminate and pistillate flowers, five sepals and five petals and a racemose inflorescence. The pistil must have been ten-carpellate with an inferior ovary and a drupaceous fruit maturing therefrom with ten seeds with smooth bony coats. Anatomically the ancestor probably possessed medullary rays of Heterogeneous type I, angular vessels with thin and uneven walls, a length to width ratio of 35:1 or more, an end-wall angle of 8° or 9°, and over 75 bars per perforation plate. The side-wall pits must have been scalariform and part elliptic-elongate. Fiber tracheids were present, probably predominant. This common ancestor is remote from the Nyssoidae (see fig. 1).

The relationships, particularly in regard to species, as here presented must be considered as highly speculative. The consideration will achieve completion only after all aspects are examined, particularly those relating to ontogeny of individual species, cytology, and the limits of variability in specific ranges. The fossil record is revealing more and more information and it is hoped that more light will be shed on possible relationships of these genera, both among themselves and exterior to *Nyssaceae*, by future research.

SUMMARY

1. Nyssaceae as a family, shows anatomical features which appear more primitive than the morphological characters.

2. The three genera fall into two groups. The most primitive group consists of *Davidia* and the advanced group consists of *Nyssa* and *Camptotheca* in phylogenetic sequence. This assumption is based on anatomical and morphological evidence.

3. The origin of the family appears to be polyphyletic and possibly far Eastern.

4. The affinity between *Nyssa* and *Camptotheca* is considerably closer than that of either with *Davidia*.

5. Anatomical evidence is in general agreement with the morphological evidence as it relates to the problem of evolution within the family.

ACKNOWLEDGEMENT

I am indeed grateful to Dr. J. E. Adams of the University of North Carolina under whose guidance this research was accomplished. The indebtedness of the writer to the curators of herbaria at the National Herbarium, the New York Botanical Garden, the University of North Carolina, and the Yale School of Forestry for specimens furnished is large.

BIBLIOGRAPHY

BAILLON, H. 1877. Histoire des Plantes, v. VI: 280.

BENTHAM, G., AND J. D. HOOKER. 1883. Genera Plantarum, v. III: 847–48. Reeve and Company, London.

CHALK, L., AND M. M. CHATTAWAY. 1934. Measuring the Length of Vessel Members. Trop. Woods **40**: 19–26.

COX, H. T. 1948. Studies in the Comparative Anatomy of the Ericales. 1. Ericaceae-sub-family Rhododendroideae. Amer. Mid. Naturalist **38**: 220–245.

COULTER, J., AND A. W. EVANS. 1890. A Revision of the Cornaceae. Bot. Gaz. **15**: 86–97.

DODE, L. A. 1908. Arbores et fructices novi. Bull. Soc. Bot. de France **55**: 651.

ENGLER, A. 1909. Syllabus der Pflanzenfamilien. ed. 6, p. 179.

ENDLICHER, S. 1838. Genera Pfl.

FROST, F. H. 1930. Specialization in the secondary xylem of dicotyledons. I. Origin of the vessel. Bot. Gaz. **89**: 67–94.

——— 1930a. Specialization in the secondary xylem of dicotyledons. II. Evolution of the end wall of the vessel segment. Bot. Gaz. **90**: 198–212.

——— 1931. Specialization in the secondary xylem of dicotyledons. III. Specialization of lateral wall of vessel segment. Bot. Gaz. **91**: 88–89.

GILBERT, S. 1940. Evolutionary significance of ring porosity in woody angiosperms. Bot. Gaz. **102**: 105–120.

HARMS, H. 1898. Cornaceae *in* Engler and Prantl, Die natürlichen Pflanzenfamilien **3**: Abt. 8: 257–260.

HORNE, A. S. 1914. Some contributions to the study of the flower. Trans. Linn. Soc. of London, ser. 2, **8**.

HUTCHINSON, J. 1926. Families of Flowering Plants. I. Dicotyledons. Macmillan and Co., London.

JOHANSEN, D. A. 1940. Plant Microtechnique. McGraw-Hill, New York.

KRIBS, D. A. 1935. Salient lines of structural specialization in the woody rays of dicotyledons. Bot. Gaz. **96**: 547–557.

MICHAUX, A. 1857. North American Sylva (trans. by Jay Smith) **3**: 29–38. Rice and Hart, Philadelphia.

RECORD AND HESS. 1943. Timbers of the New World, pp. 411–413. Yale University Press, New Haven, Conn.

REHDER, A. 1930. *In* Bailey, Standard Cyclopedia of Horticulture **1**: 973. Macmillan Company, New York.

RENDLE, B. J., AND S. H. CLARK. 1934. The diagnostic value of measurements in woody anatomy. Trop. Woods **40**: 27–37.

SARGENT, J. 1893. The Silva of North America **5**: 73–84. Houghton Mifflin and Company, Boston and New York.

SCHIMPER, A. F. W. 1903. Plant Geography (trans. by Wm. Fisher). Clarendon Press, Oxford.

SCOTT, D. H. 1900. Studies in Fossil Botany. A. and C. Black, London.
SMALL, J. K. 1933. Manual of the Southeastern Flora, pp. 956–958. Published by the author.
SOLEREDER, H. 1908. Systematic Anatomy of the Dicotyledons (trans. by L. A. Boodle and F. E. Fritsch). Clarendon Press, Oxford.
TIPPO, O. 1938. Comparative anatomy of the Moraceae and their presumed allies. Bot. Gaz. 100: 1–99.
WANGERIN, W. 1910. Nyssaceae *in* Engler, Das Pflanzenreich 4(220a): 1–19.
WARMING, E. 1913. Observations on the Systematic Value of the Ovule, *in* Saertryk af Mindeskrift for Japetus Steerstrup. Copenhagen.

AN ANNOTATED LIST OF WASPS FROM NAGS HEAD AND THE KILL DEVIL HILLS

(Hymenoptera Aculeata)

By Karl V. Krombein

Arlington, Virginia

During the period May 23–June 5, 1948 our family stayed at Nags Head, Dare County, North Carolina. This locality is on a narrow sand reef ranging up to about a mile in width and is separated from the mainland by shallow Albemarle Sound. I collected a total of 88 species of wasps during our short stay, almost one-fifth the number of species recorded from the entire state in the State List and Supplement.[1] Of these 88 species, 23 have not been recorded from North Carolina previously, and two genera and one subgenus are also new to the State List. Since the State List includes very meagre coastal records, and since so many of the species I collected were not recorded previously from North Carolina, I considered it worthwhile to prepare the following list.

Collections the first three days were made around Nags Head. The vegetation there is principally sea oats (*Uniola paniculata*) with occasional stands of shrubby bayberry (*Myrica carolinensis*) and *Ilex vomitoria*, and the fauna is correspondingly sparse. The following afternoons through June 2nd (May 29, 31, June 1 and 3 were overcast or stormy with high winds and no collecting was done) collections were made on the low flat area between the dunes and the ocean in the area around Kill Devil Hills. This area, while having a rather barren appearance, supports a diverse vegetation of which the dominant shrubs are *Ilex vomitoria*, bayberry, and live oak (*Quercus virginiana*). West of the dunes is a rather densely wooded area with sandy loam soil which is gradually being encroached upon by the shifting dunes. Collections were made in this environment on June 4th and 5th only, and the list of species would undoubtedly be longer had more time been spent in the woods.

It should be pointed out that the spring of 1948 was a week or two later than normal along the Atlantic Coast. One would normally expect in this latitude to find species of those sand-loving genera, *Oxybelus*, *Bembix*, and *Tachytes*, present by June 1st, but this was not the case in 1948. Collections made during mid-summer probably would more than double the number of species listed here.

The taxonomic arrangement in the following list is that used in the State List to facilitate cross reference, though nomenclatorial changes have been made to conform to usage at present. Genera and species marked with an asterisk have not been recorded from the state previously. I am indebted to H.

[1] "The Insects of North Carolina", by C. S. Brimley, N. C. Dept. Agr. unnumbered publ., 1938, and "Supplement to Insects of North Carolina", by C. S. Brimley, N. C. Dept. Agr. unnumbered publ., 1942.

K. Townes, H. E. Evans, R. M. and G. E. Bohart for confirming or making identifications in several genera as indicated.

Family POMPILIDAE (PSAMMOCHARIDAE of State List)

CEROPALES Latreille

C. bipunctata Say. Kill Devil Hills, 5 ♂♂, May 28–June 4, on sandy barrens around foliage, principally *Salix*.

AGENIELLA Banks

**A. faceta* (Cresson) (det. H. K. Townes). Kill Devil Hills, 1 ♂, June 5, in woods.

DIPOGON Fox (PSEUDAGENIA, in part, of State List)

D. pulchripennis (Cresson). Kill Devil Hills, 1 ♀, May 28, on sandy barrens.

PRIOCNEMIS Schiødte

P. pomilius (Cresson) (= *pompilus* (!) of State List). Nags Head, 1 ♀, May 24. Kill Devil Hills, 32 ♀♀, 15 ♂♂, on sandy barrens.

APORINELLUS Banks[1]

A. fasciatus (Smith). Nags Head, 6 ♀♀, 4 ♂♂, May 23–25. Kill Devil Hills, 4 ♀♀, 2 ♂♂, May 26–June 5, on sandy barrens.

* *A. taeniatus* (Kohl). Nags Head, 3 ♀♀, May 23–25. Kill Devil Hills, 3 ♀♀, May 26–27, on sandy barrens.

PSORTHASPIS Banks (PEDINASPIS of State List)

P. legata (Cresson). Kill Devil Hills, 1 ♂, June 5, in woods.

EPISYRON Schiødte

E. biguttatus (Fabricius). Kill Devil Hills, 1 ♀, June 2, on edge of woods.

E. posterus (Fox). Kill Devil Hills, 2 ♀♀, 1 ♂, June 2–5, on edge of woods and in woods.

E. snowi (Viereck). Kill Devil Hills, 3 ♀♀, May 28–30, on sandy barrens.

SERICOPOMPILUS Ashmead

S. cinctipes (Cresson). Kill Devil Hills, 5 ♀♀, 8 ♂♂, May 27–June 5, the females in the woods, the males on edge of woods or on sandy barrens.

POMPILUS Fabricius (PSAMMOCHARES, in part, of State List)

P. rectus (Banks). Kill Devil Hills, 2 ♀♀, June 5, in woods.

SOPHROPOMPILUS Howard

S. hyacinthinus (Cresson). Nags Head, 1 ♂, May 24. Kill Devil Hills, 15 ♀♀, 3 ♂♂, May 26–June 5, on sandy barrens and edge of woods.

[1] Determinations in this and the following genera of the Pompilidae were confirmed or made by H. E. Evans.

* *S. minusculus* (Banks). Nags Head, 4 ♀♀, 1 ♂, May 24–25. Kill Devil Hills, 4 ♀♀, May 26–30, on sandy barrens.

ANOPLIUS Dufour (PSAMMOCHARES, in part, of State List)

Subgenus LOPHOPOMPILUS Radoszkowski

A. cleora (Banks). Kill Devil Hills, 1 ♀, June 4, on sandy barrens.

A. bengtssoni (Regan). Kill Devil Hills, 4 ♂♂, May 28–June 5, on sandy barrens and in woods.

A. bengtssoni (Regan). Kill Devil Hills, 4 ♂♂, May 28–June 5, on sandy barrens and in woods.

Subgenus NOTIOCHARES Banks

A. philadelphicus (Lepeletier). Kill Devil Hills, 1 ♀, 3 ♂♂, May 26–June 5, on sandy barrens.

Subgenus ARACHNOPHROCTONUS Howard, not Ashmead

(PSAMMOCHARES and POMPILOIDES, in part, of State List)

A. americanus (Beauvois). Kill Devil Hills, 2 ♂♂, May 27–28, on sandy barrens.

A. marginalis (Banks). Kill Devil Hills, 1 ♀, 1 ♂, June 2–4, on sandy barrens.

A. pretiosus (Banks). Kill Devil Hills, 11 ♀♀, 15 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

A. relativus (Fox). Nags Head, 1 ♀, 4 ♂♂, May 24–25. Kill Devil Hills, 14 ♀♀, 20 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

A. semirufus (Cresson). Kill Devil Hills, 3 ♀♀, 1 ♂, June 2–5, mostly in woods, one on edge of woods.

Subgenus ANOPLIUS Dufour

* *A. ventralis* (Banks). Kill Devil Hills, 1 ♀, 1 ♂, May 28, on sandy barrens.

Subgenus POMPILINUS Ashmead (POMPILOIDES, in part, of State List)

A. cylindricus (Cresson). Nags Head, 2 ♀♀, May 24–25. Kill Devil Hills, 10 ♀♀, 1 ♂, May 26–June 5, mostly on sandy barrens, one in woods, and one on edge of woods.

A. marginatus (Say). Kill Devil Hills, 1 ♂, June 5, in woods.

* *A. splendens* (Dreisbach). Kill Devil Hills, 3 ♂♂, May 28–June 5, two on sandy barrens, one in woods.

* *A. subcylindricus* (Banks). Kill Devil Hills, 3 ♀♀, May 26–28, on sandy barrens.

* *A.* n. sp. (to be described by H. E. Evans). Nags Head, 4 ♂♂, May 25. Kill Devil Hills, 20 ♀♀, 12 ♂♂, May 26–June 4, on sandy barrens.

Family RHOPALOSOMATIDAE

* OLIXON Cameron

* *O. banksii* (Brues), new combination, transferred from *Nealgoa*. Kill Devil Hills, 29 ♂♂, May 26–June 5. These interesting brachypterous males were

running swiftly over the sandy barrens. The reasons for the generic transfer and family assignment will be discussed in a separate paper. The species has been taken but rarely, and I know of only five other specimens including the type, all females except one.

Family TIPHIIDAE

TIPHIA Fabricius

* *T. convexa* Allen. Kill Devil Hills, 8 ♀♀, 9 ♂♂, June 4–5, all in woods except one on edge of woods.

T. hollowayi Allen. Kill Devil Hills, 12 ♂♂, June 4–5, on sandy barrens.

* PARATIPHIA Sichel

* *P. algonquina* Viereck. Kill Devil Hills, 1 ♀, 13 ♂♂, June 4–5, on sandy barrens.

Family MUTILLIDAE

PSEUDOMETHOCA Ashmead

P. frigida (Smith) (= *canadensis* of State List). Kill Devil Hills, 2 ♀♀, June 2–5, one in woods, one on edge of woods.

P. sanbornii (Blake). Kill Devil Hills, 2 ♀♀, June 5, in woods.

P. simillima (Smith). Kill Devil Hills, 20 ♀♀, May 26–June 5, mostly on sandy barrens, but some in woods.

P. vanduzeei Bradley. Kill Devil Hills, 1 ♀, June 5, in woods.

DASYMUTILLA Ashmead

D. lepeletierii (Fox). Kill Devil Hills, 1 ♂, June 5, on sandy barrens.

D. mutata (Blake) (= *allardi* of State List). Kill Devil Hills, 2 ♀♀, June 5, in woods.

D. nigripes (Fabricius) (= *sparsa* and *sparsa segregata* of State List). Kill Devil Hills, 4 ♀♀, June 5, in woods.

D. vesta (Cresson). Kill Devil Hills, 1 ♀, June 5, in woods.

TIMULLA Ashmead

T. dubitata dubitata (Smith). Nags Head, 1 ♀, May 24. Kill Devil Hills, 11 ♀♀, May 26–June 5, mostly on sandy barrens, a couple in woods.

T. dubitatiformis Mickel. Kill Devil Hills, 2 ♀♀, May 28, on sandy barrens.

T. ferrugata (Fabricius). Nags Head, 2 ♀♀, May 24. Kill Devil Hills, 12 ♀♀, May 26–June 5, all on sandy barrens, except one in woods.

T. ornatipennis Bradley. Kill Devil Hills, 3 ♀♀, June 2–4, one on sandy barrens, two on edge of woods.

EPHUTA Say

E. sp. Kill Devil Hills, 5 ♀♀, May 27–30, on sandy barrens.

E. sp. Kill Devil Hills, 3 ♀♀, June 5, in woods.

The two species listed above are distinct in sculpture, type of environment preferred, and actions, but since males were not collected I am unable to name them at present.

Family SCOLIIDAE

CAMPSOMERIS Lepeletier

C. plumipes fossulana (Fabricius). Kill Devil Hills, 1 ♀, June 4, in woods.

Family VESPIDAE

Subfamily ZETHINAE

ZETHUS Fabricius

Z. variegatus Saussure. Kill Devil Hills, 2 ♂♂, May 30, on edge of woods.

Subfamily EUMENINAE

MONOBIA Saussure

M. quadridens (Linnaeus). Kill Devil Hills, 1 ♀, 1 ♂, May 27–June 2, on edge of woods. Others seen on edge of woods and in woods.

RYGCHIUM Spinola (ODYNERUS, in part, of State List)

R. foraminatum (Saussure). Kill Devil Hills, 2 ♀♀, May 30–June 5, in woods and on edge of woods.

* *R. manifestum* (Saussure). Kill Devil Hills, 1 ♀, 5 ♂♂, May 28–June 5, mostly on sandy barrens, one on edge of woods.

R. megaera (Lepeletier). Kill Devil Hills, 3 ♀♀, 5 ♂♂, May 27–June 5, mostly on edge of woods or in woods.

STENODYNERUS[3] Saussure (ODYNERUS, in part, of State List)

* *S. ammonia histrionalis* (Saussure). Nags Head, 2 ♂♂, May 24. Kill Devil Hills, 4 ♀♀, 11 ♂♂, May 26–June 4, on sandy barrens.

S. fulvipes (Saussure). Kill Devil Hills, 2 ♂♂, June 5, in woods.

* *S. histrio* (Saussure). Kill Devil Hills, 5 ♀♀, 2 ♂♂, May 30–June 5, females in the woods, males on the edge of the woods.

* *S. lineatifrons* Bohart. Kill Devil Hills, 5 ♀♀, 15 ♂♂, May 26–June 5, on sandy barrens.

S. pedestris (Saussure). Kill Devil Hills, 4 ♀♀, June 2–5, mostly on edge of woods or in woods.

* *S.* n. sp. (to be described by R. M. Bohart). Kill Devil Hills, 4 ♀♀, 2 ♂♂, May 26–June 5, mostly on sandy barrens, two on edge of woods.

LEPTOCHILUS Saussure

* *L. monotylus* Bohart. Kill Devil Hills, 4 ♀♀, 4 ♂♂, June 2–5, on sandy barrens and in woods.

[3] Determinations in this genus were confirmed or made by R. M. Bohart.

Subfamily POLISTINAE

POLISTES Latreille

P. fuscatus fuscatus (Fabricius). Kill Devil Hills, 2 ♀♀, May 26, on sandy barrens.

P. hunteri Bequaert (= *minor* Auctt., of State List). Kill Devil Hills, 1 ♀ May 30, on edge of woods.

P. metricus Say. Kill Devil Hills, 2 ♀♀, May 26–June 2, on sandy barrens and on edge of woods.

Many other individuals of these three species were seen but not taken.

Subfamily VESPINAE

VESPULA Thomson

V. squamosa (Drury). Kill Devil Hills, 1 ♀, June 2, on edge of woods.

Family SPHECIDAE

Subfamily LARRINAE

Tribe Larrini

MOTES Kohl (NOTOGONIDEA of State List)

M. argentata (Beauvois). Kill Devil Hills, 2 ♂♂, May 28–June 2, one on sandy barrens and one on edge of woods.

TACHYSPHEX Kohl

* *T. similis* Rohwer. Nags Head, 1 ♂, May 24. Kill Devil Hills, 7 ♀♀, 6 ♂♂, May 26–June 5, all on sandy barrens except two females in woods.

T. tarsatus (Say). Nags Head, 2 ♀♀, 1 ♂, May 23–25. Kill Devil Hills, 1 ♀, 11 ♂♂, May 26–June 5, on sandy barrens.

T. terminatus (Smith). Nags Head, 11 ♀♀, 9 ♂♂, May 23–25. Kill Devil Hills, 21 ♀♀, 8 ♂♂, May 26–June 5, mostly on sandy barrens, a few on edge of woods.

* *T.* n. sp. (to be described by G. E. Bohart). Nags Head, 3 ♂♂, May 23–24.

* *T.* n. sp. (to be described by G. E. Bohart). Kill Devil Hills, 2 ♀♀, May 27–28, on sandy barrens.

Tribe Dinetini

LYRODA Say

L. subita Say. Kill Devil Hills, 1 ♀, June 5, on sandy barrens.

Subfamily TRYPOXYLONINAE

TRYPOXYLON Latreille

T. rubrocinctum Packard. Kill Devil Hills, 1 ♀, June 5, in woods.

Subfamily SPHECINAE

CHLORION Latreille

Subgenus PALMODES Kohl

C. abdominalis (Cresson). Kill Devil Hills, 1 ♂, June 4, on sandy barrens.

Subgenus PRIONONYX Dahlbom

C. pubidorsum (Costa). Kill Devil Hills, 2 ♀♀, 23 ♂♂, May 26–June 4, on sandy barrens, a few on edge of woods. Extremely common, and many more could have been taken.

Subgenus ISODONTIA Patton

C. auripes Fernald. Kill Devil Hills, 1 ♂, June 2, on edge of woods.
C. aztecum aztecum (Saussure). Kill Devil Hills, 1 ♀, June 5, in woods.

SPHEX Linnaeus

S. procerus (Dahlbom). Kill Devil Hills, 5 ♂♂, May 28–June 5, on sandy barrens and in woods.

SCELIPHRON Klug

S. caementarium (Drury). Nags Head, 1 ♂, May 25.

Subfamily PSENINAE

Tribe Psenini

PLUTO Pate (= PSENIA Malloch, preoccupied, of State List)

* ***Pluto arenivagus***, new species

Psenia angulicornis Malloch, in part, 1933. Proc. U. S. Natl. Mus. **82**, Art. 26: 48 (labeled var. in key), 58; (♀; Tifton, Georgia, paratype only).

This species appears to be most closely related to *tibialis* (Cresson). The male runs in Malloch's key to *tibialis*, but is distinguished without difficulty by the fact that linear tyloides are present on flagellar segments two through ten (complete except for that on tenth), while in *tibialis* these are present only on segments two or three through eight (complete except for that on eighth). The female runs to couplet 24 in Malloch's key, but is distinguished from *brevipetiolata* (Rohwer) and *pallidistigma* (Malloch) by having the occipital and hypostomal carinae contiguous, whereas they are well separated in those two species. The female has much the aspect of a *tibialis* with red on the abdomen, but lacks the prominent tooth laterally on the pronotum.

Type: ♂; Kill Devil Hills, Dare County, North Carolina; May 28, 1948; (K. V. Krombein; on sandy barrens).

Male.—Length 6.7 mm., forewing 3.7 mm. Black; fore and hind femora beneath, mid femur at tip, all tibiae, and apices of abdominal segments very narrowly, reddish; tegulae testaceous; flagellum brownish beneath, paler on three apical segments; apex of pronotal lobe, spot at base of hind tibia, tibial spurs, and all tarsi except last segment, white to creamy. Vestiture silvery,

short, dense and appressed on clypeus, erect and sparse elsewhere on head, erect and moderately dense on thorax, appressed on abdomen.

Head dull; vertex and temples finely striatopunctate; antennal flagellum stout but not clubbed, complete linear tyloides beneath on segments two to nine and a partial one on tenth.

Thorax dull; pronotum crested but lateral angles not dentate; scutum not rugose, with large, rather dense punctures, the interspaces lineolate; scutellum with sparser, slightly smaller punctures; postscutellum very finely and closely punctate; mesopleuron with large, mostly contiguous punctures, where interspaces are present they are lineolate; propodeal sculpture much as in *tibialis*, the enclosure well marked, with irregular reticulations, the areas adjacent to enclosure likewise irregularly reticulate but the mesh smaller.

Abdomen shining, the petiole 0.78 the length of hind femur.

The male paratypes vary in length from 6.7 to 6.9 mm., and agree very well in details of sculpture and coloration.

Allotype: ♀; same data as type but May 27, 1948.

Female.—Length 7.7 mm., forewing 4.1 mm. Similar in color and vestiture to male with the following exceptions: Femora black except at apices beneath; fore and mid tibiae with a creamy stripe on outer surface; apex of first abdominal tergite, all of second and base of third segments, ferruginous; flagellum light brown beneath on apical seven segments.

Sculpture similar to male with the following exceptions: Flagellum clubbed, tyloides absent; petiole of abdomen 0.64 the length of hind femur; pygidial area not twice as long as its greatest width (1.8:1).

The female paratypes vary from 6.4 to 7.0 mm. (the Georgia specimen), the pygidial area is about twice as long as its greatest width, and the third abdominal segment of the Georgia specimen is almost completely ferruginous.

Paratypes: 1♂, 1♀; same data as type, but May 27, 1948 (♂) and May 30, 1948 (♀). 1♂; Nags Head, Dare County, North Carolina; May 24, 1948; (K. V. Krombein). 1 ♀; Tifton, Tift County, Georgia; (Ashmead collection); (labeled *angulicornis* paratype var.).

The type and allotype are placed on loan deposit in the collection of the U. S. National Museum. The remaining paratypes from North Carolina are in my personal collection, and the Tifton, Ga., paratype is in the U. S. National Museum.

Subfamily BEMBICINAE

Tribe Nyssonini

ALYSON Jurine

A. melleus Say. Kill Devil Hills, 2 ♀♀, 1♂, May 26–30, on sandy barrens.

GORYTES Latreille

*** *Gorytes* (*Gorytes*) *dorothyae*[1], new species**

The present form, known only from the male, is a member of a complex of

[1] For my wife.

closely related species including in the east, *simillimus* Smith and *gyponacinus* Rohwer. Superficially it may be separated from those two forms by the more extensive yellow maculations on the head and legs—in *dorothyae* the mandibles are almost entirely yellow except at extreme tip and base (entirely black or with only a small subbasal spot yellow in the other two species), the clypeus is entirely yellow (apical margin black in the other two), no rather broad black band along subantennal suture (almost always present in the other two), mid and hind coxae entirely yellow except narrowly at base (black except occasionally at apex beneath in the other two), and mid and hind trochanters usually yellow beneath (black in other two). In addition, the rugae on the propodeal enclosure usually extend halfway to the apex in *dorothyae* (present only at extreme base in other two species), rather broad tyloides are present on the first to fourth flagellar segments and a linear one on the fifth (narrower ones on the first or second to third and a linear one on the fourth in the other two), the postscutellum is not foveolate at base (base of postscutellum foveolate in the other two), and the metapleural-propodeal suture is foveolate between the upper and lower metapleural pits (foveolate only above the upper metapleural pit in the other two).

Type: ♂; Kill Devil Hills, Dare County, North Carolina; May 30, 1948; (K. V. Krombein; on edge of woods).

Male.—Length 9.2 mm., forewing 7.3 mm. Black, shining; the following bright lemon yellow—palpi, mandible except extreme base and tip, clypeus, front below antennae and a narrow strip along inner eye margin extending from level of antennae halfway to ocelli, scape entirely, pedicel except a small spot above, transverse band on pronotum, pronotal tubercle, small spot posterolaterally on scutum, spot on base of tegula, apical half of scutellum, large spot on upper anterior part of mesopleuron, large lateral spot on propodeum, fore coxa and trochanter beneath at apex, all of mid and hind coxae except extreme base, mid and hind trochanters beneath, fore and mid femora beneath and at apex above, narrower stripe beneath on hind femora shading to reddish anteriorly, fore and mid tibiae, tibial spurs and tarsi entirely, hind tibia beneath, apical bands on tergites one to five, those of first and second the widest, the others progressively narrower, that on first abruptly narrowed in middle, of second slightly narrowed in middle, second sternite with apical band narrow except laterally, and small posterolateral spots on third and fourth sternites; tyloides on first four flagellar segments and hind tarsi beneath, reddish. Wings hyaline, marginal cell infumated.

Interocular distance at base of clypeus slightly less than height of clypeus in center (7.3:7.8) and slightly less than half the interocular distance at level of anterior ocellus (7.3:15); flagellum moderately long, intermediate segments about twice as long as apical width of each, the first four segments more strongly rounded out beneath than in *simillimus*, tyloides on segments one to four broader than in *simillimus*, that on fifth linear.

Thoracic sculpture very similar to *simillimus* with the following exceptions: Base of postscutellum not foveolate; propodeal enclosure with about a dozen longitudinal ridges on basal half; metapleural-propodeal suture foveolate be-

tween upper and lower metapleural pits (this suture foveolate only above upper metapleural pit in *simillimus* and *gyponacinus*).

Details of abdominal punctation much as in *simillimus* except that punctures on second to sixth tergites are of two distinctly different sizes, rather dense fine ones with scattered larger ones (the scattered larger ones on tergites three to six in *simillimus* and *gyponacinus* evanescent, or at least not readily discernible).

Male paratypes vary in length from 7.7 to 9.2 mm. and show the following differences in coloration: There is usually a dark spot on scape above; trochanters and hind femora beneath may occasionally lack yellow; the band on fifth tergite is lacking in one specimen; the band on second sternite is occasionally reduced to small lateral spots, and the spots on third and fourth sternites are lacking in these specimens. There are slight variations in structural characters as follows: Tyloid of first flagellar segment may be present only on apical third of segment; and the ridges on propodeal enclosure may extend only one-third the distance to apex, or as much as two-thirds (in any case they are always better developed than in any *simillimus* or *gyponacinus* I have seen).

Paratypes: 4♂♂; same data as type. 1♂; same data as type, but June 2, 1948. 2 ♂♂; same data as type, but June 5, 1948; collected in woods.

The type is placed on loan deposit in the collection of the U. S. National Museum, and the paratypes are in my personal collection.

PSAMMAECIUS Lepeletier (GORYTES, in part, of State List)

P. nebulosus (Packard). Kill Devil Hills, 1 ♀, 8 ♂♂, May 30–June 5, in woods and on edge of woods.

NYSSON Latreille

N. opulentus Gerstaecker. Kill Devil Hills, 1 ♂, June 5, in woods.

Tribe **Cercerini**

CERCERIS Latreille

C. robertsoni Fox. Kill Devil Hills, 1♀, 1♂, June 5, female in woods, male on sandy barrens.

Tribe **Bembicini**

MICROBEMBEX Patton

M. monodonta (Say). Kill Devil Hills, 2 ♂♂, May 30, on edge of woods. Common later on sandy barrens.

Subfamily CRABRONINAE

Tribe **Crabronini**

CRABRO Fabricius

Subgenus PARANOTHYREUS Kohl (Subgenus THYREOPUS, in part, of State List)

C. hilaris Smith. Kill Devil Hills, 2♀♀, 11 ♂♂, on sandy barrens, most males around scrub oak (*Quercus marilandica*) foliage.

* Subgenus NORUMBEGA Pate

* *C. argus* Packard. Kill Devil Hills, 3 ♀♀, 9 ♂♂, May 30–June 5, in woods, and on sandy barrens around scrub oak foliage.

ECTEMNIUS Dahlbom (Subgenus CRABRO, of State List)

Subgenus HYPOCRABRO Ashmead

E. decemmaculatus (Say). Nags Head, 1 ♀, 3 ♂♂, May 24–28. Kill Devil Hills, 3 ♀♀, 19 ♂♂, May 26–June 5, on sandy barrens. One male is a melanic, having lost most of the pale markings on the body.

* *E. scaber* (Lepeletier and Brullé). Kill Devil Hills, 1 ♀, 1 ♂, May 26–June 5, the female in woods, male on sandy barrens.

A NEW SPECIES OF CALANOID COPEPOD FROM NORTH CAROLINA

By W. H. Sutcliffe, Jr.[1]

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Introduction. In connection with a shrimp survey and other research on the marine resources of North Carolina, plankton tows were made from the survey vessel *Penny* of the North Carolina Institute of Fisheries Research. The copepod described in this paper was collected in a surface tow on April 20, 1949 in shallow water (about 8 fathoms) south southwest of New River Inlet, North Carolina.

Family PONTELLIDAE

Genus ANOMALOCERA Templeton

Anomalocera ornata new species

Types. Holotype, female, U.S.N.M. No. 89602; allotype, male, U.S.N.M. No. 89603; paratypes, 1 male and 3 females, U.S.N.M. No. 89604; locality, Lat 34°22.5′ N, Long 77°22′ W, surface plankton.

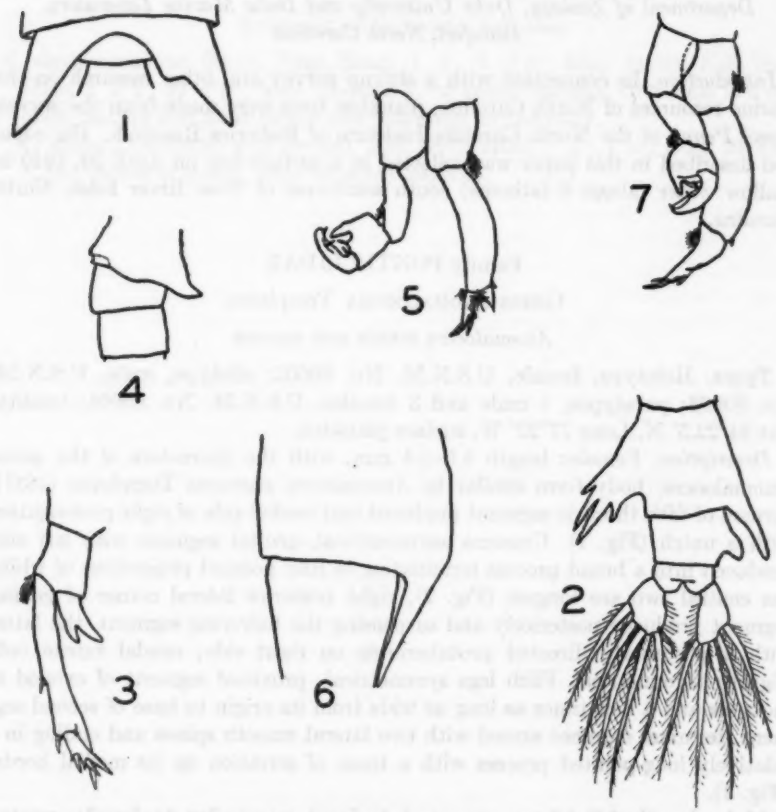
Description. Female: length 4.0–4.4 mm, with the characters of the genus Anomalocera, body form similar to *Anomalocera patersoni* Templeton (1837), corners of fifth thoracic segment produced and medial side of right prolongation with a notch (Fig. 1). Urosome asymmetrical, genital segment with left side produced into a broad process terminating in four pointed projections of which the central two are longest (Fig. 2); right posterior lateral corner of genital segment produced posteriorly and surpassing the following segment, the latter with a posteriorly directed protuberance on right side; caudal furcae only slightly asymmetrical. Fifth legs symmetrical, proximal segment of exopod at most six and a half times as long as wide from its origin to base of second segment, terminal segment armed with two lateral smooth spines and ending in a relatively long-pointed process with a trace of serration on its medial border (Fig. 3).

Male: length 4.2–4.3 mm, general body shape similar to female; ventral eye much more prominent and larger; prolongation of fifth thoracic segment more asymmetrical, right much more produced than left and curved inward and slightly upward; genital segment of urosome produced on right posterior and ending in a point directed almost at right angles to urosome (Fig. 4). Right first antenna forming a grasping organ similar to *Anomalocera patersoni*. Fifth legs asymmetrical (Fig. 5), third segment of left leg bifurcate, medial portion about twice the length of lateral, medial portion terminated in a sharp point and equipped with three spines on lateral side, two setose projections near base

[1] The writer is indebted to Mr. C. E. Atkinson, Director of the U. S. Fish and Wildlife Laboratory at Beaufort, N. C., for bringing the specimens to his attention.

of segment; chela of right leg roughly quadrate and with a short thumb and a long curved finger, the latter with three small spines in its inner edge.

Remarks. The most distinctive characteristic separating *Anomalocera ornata* from *A. patersoni* is the projection from the left side of the genital segment of



FIGS. 1–7. 1. Fifth thoracic segment, female, *Anomalocera ornata*. 2. Urosome, female, *A. ornata*. 3. Fifth leg, female, *A. ornata*. 4. Portion of urosome showing projection from genital segment, male, *A. ornata*. 5. Fifth legs, male, *A. ornata*. 6. Portion of urosome showing genital and following segment, female, *A. patersoni*. 7. Fifth legs, male, *A. patersoni*.

the female; *A. patersoni* lacks any such protuberance (Fig. 6). *A. patersoni* has symmetrical corners on the fifth thoracic segment with respect to the medial notch found on the right side of *A. ornata*. *A. ornata* has only slight serrations on the medial termination of the distal exopod segment of the fifth legs, whereas *A. patersoni* is distinctly toothed. In addition, the proximal exopod segment of the fifth leg is of different proportions in the two species; with *A. ornata* at

most six and a half times as long as wide, with *A. patersoni* eight to eight and a half times as long as wide.

In the male the character of the fifth legs as well as the genital segment will distinguish the two species. The differences of the terminal segment of the left fifth legs as well as the extra spine which *A. ornata* has on the finger of the chela are seen in Figs. 5 and 7. The projection on the right side of the genital segment differs in the two species. In *A. ornata* the projection is more or less broadly triangular with the tip directed nearly at right angles to the urosome (Fig. 4); in *A. patersoni* this projection is long, acuminate, and directed posteriorly.

LITERATURE CITED

TEMPLETON, ROBERT. 1837. Description of a new Irish crustaceous animal. Trans. Ent. Soc. Lond. 2: 34–40.

STUDIES IN THE COMPOSITAE OF NORTH CAROLINA

II. The Compositae of Wake, Durham, and Orange Counties*

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INTRODUCTION

This annotated catalogue, with keys, represents an attempt to present a useful local treatment of the Compositae. For students who are attempting to learn the local representatives of a large plant family, the advantages of a treatment of a restricted area are several. For example, it is less cumbersome to use than a manual covering a region which is geographically extensive and physiographically complex, and it gives more definite and tangible data regarding distribution of the taxonomic entities within the area covered.

Small's Manual (1933) is the most recent complete study including the small area under consideration here. Blomquist and Oosting's guide (1948) includes all of the area except the portion of Wake County which is on the coastal plain, but it does not purport to treat the late summer and fall flora. A great many of the composites bloom in the late summer and autumn; many of them are, therefore, not included in it.

The plant names used in this catalogue are those considered to be most generally acceptable under the established rules of botanical nomenclature. Many of them are at variance with the names in Small's Manual. Inasmuch as anyone who uses this treatment will often wish to consult that manual for detailed descriptions and general range data, synonyms are given in the listing of the species wherever practicable. In the few instances where a species or variety is one which has been described since the publication of the Manual, the name, as listed, is preceded by an asterisk and followed by the year of the literature citation in which its original description is to be found.

This study is based primarily upon collections from Wake, Durham, and Orange Counties, North Carolina, which are deposited in the herbaria of North Carolina State College, Duke University, and the University of North Carolina, which institutions are respectively located in those counties as named. Distribution notes are, for the most part, in terms of habitats and are based largely upon the author's field observations rather than upon data as given on herbarium sheet labels. Definite range limits within the area are defined only when there seems to be evidence that a species is restricted in its occurrence to some small portion of it. It is to be expected that other species, particularly in the larger genera, will be found to occur in the area.

* For the first paper in this series, see Godfrey, *Studies in the Compositae of North Carolina, I. Liatris*, Jour. Elisha Mitchell Sci. Soc. 64: 241–249. 1948.

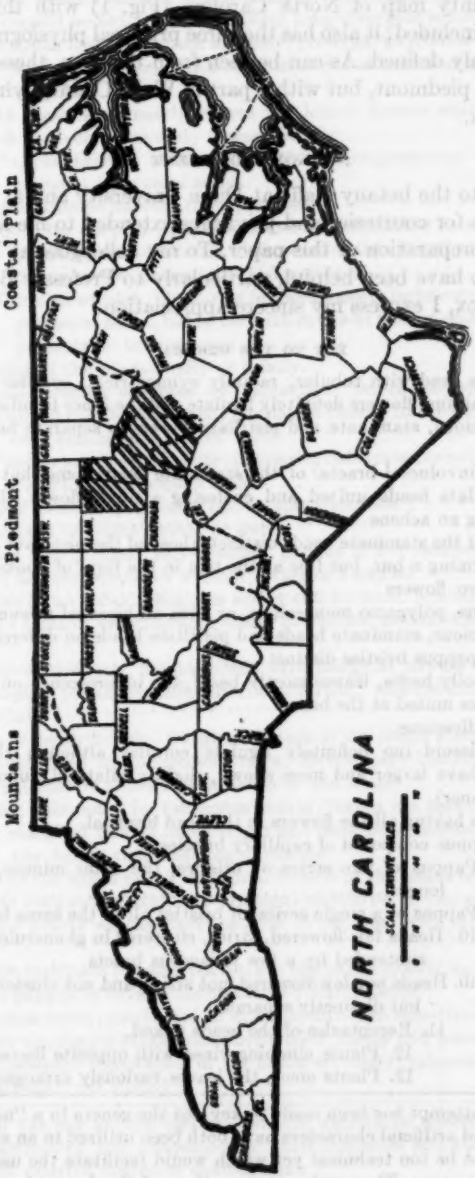

FIG. 1. Outline map showing area covered by this study shaded-in.

An outline county map of North Carolina (Fig. 1) with this three-county area shaded-in is included; it also has the three principal physiographic provinces of the state roughly defined. As can be seen from the map, these three counties are largely on the piedmont, but with a part of Wake County lying on the innermost coastal plain.

ACKNOWLEDGEMENT

I am indebted to the botany staffs at Duke University and at the University of North Carolina for courtesies and privileges extended to me at those institutions during the preparation of this paper. To my colleagues at North Carolina State College who have been helpful, particularly to Professor B. W. Wells and Dr. William B. Fox, I express my sincere appreciation.

KEY TO THE GENERA*

1. All flowers of the head with tubular, radially symmetrical, corollas (heads discoid), or with the marginal flowers definitely ligulate and the inner tubular (heads radiate).
2. Plants monoecious, staminate and pistillate flowers in separate heads on the same plant.
3. Phyllaries (involucral bracts) of the staminate heads somewhat united, those of the pistillate heads united and enclosing a single flower, thus when mature simulating an achene ..... *Ambrosia* (23)
3. Phyllaries of the staminate heads distinct, those of the pistillate heads essentially united forming a bur, but free at the tips in the form of hooked spines and enclosing two flowers ..... *Xanthium* (24)
2. Plants dioecious, polygamo-monoecious, or with all bisexual flowers.
4. Plants dioecious, staminate heads and pistillate heads on different plants.
5. Shrubs; pappus bristles distinct ..... *Baccharis* (14)
5. Low, woolly herbs, leaves mostly basal, the inflorescence on a scape; pappus bristles united at the base ..... *Antennaria* (16)
4. Plants not dioecious.
6. Heads discoid (no definitely ligulate corollas although the outer flowers may have larger and more showy, slightly bilateral, tubular corollas than the inner).
7. Plants having all the flowers in the head bisexual.
8. Pappus composed of capillary bristles.
9. Pappus of two series of bristles, the outer minute, the inner much longer ..... *Vernonia* (1)
9. Pappus of a single series of bristles all of the same length.
10. Heads few-flowered, strict, clustered in glomerules, the glomerules subtended by a few foliaceous bracts ..... *Elephantopus* (2)
10. Heads not few-flowered, not strict, and not clustered in glomerules, but distinctly separate
11. Receptacles of the heads naked.
12. Plants climbing vines with opposite leaves .... *Mikania* (4)
12. Plants erect, the leaves variously arranged.

* In this key no attempt has been made to key-out the genera in a "natural" sequence. So-called natural and artificial characters have both been utilized in an attempt to make a key which would not be too technical yet which would facilitate the user's gaining some real concept of the genera.—The number in parentheses following each genus indicates the number of that genus in the sequence of the catalogue that follows.

13. Pappus bristles smooth or scabrous, but not either barbellate (with short divergent setae), or plumose (with long divergent setae).
14. Pappus bristles smooth and soft; principal phyllaries in a single series, with only a very much reduced series of bracts at the base of the involucre.
15. Leaves palmately veined and lobed; flowers white....*Cacalia* (45)
15. Leaves pinnatifid; flowers yellow.....*Senecio* (46)
14. Pappus bristles scabrous; phyllaries progressively unequal and imbricated in several series.....*Eupatorium* (3)
13. Pappus bristles barbellate or plumose.
16. Corollas purplish; phyllaries closely imbricated in several series, not striate; perennial herbs with corms or tubers and a spicate, racemose, or racemose-paniculate inflorescence.....*Liatris* (7)
16. Corollas whitish; phyllaries few and loosely imbricated, striate-nerved; perennial herbs, but never with corms or tubers, and having a cymose-paniculate inflorescence.....*Kuhnia* (5)
11. Receptacles of the heads chaffy or bristly.
17. Pappus bristles scabrous or barbellate; leaves not spiny-toothed.
18. Pappus bristles scabrous; phyllaries closely imbricated in many series, each ending in a hooked spine.....*Arctium* (47)
18. Pappus bristles barbellate; phyllaries imbricated loosely in several series, not ending in hooked spines.....*Carphephorus* (6)
17. Pappus bristles plumose; leaves spiny-toothed.....*Cirsium* (48)
8. Pappus composed of scales, teeth, or awns.
19. Phyllaries nearly equal, in 1–2 series; pappus of 5–6 membranaceous, pointed scales; flowers purple to whitish; achenes 5-angled.....*Marshallia* (35)
19. Phyllaries in an outer foliaceous series and an inner bracteous series; pappus of 2 or 4 teeth or awns; flowers yellow to whitish; achenes flattened or 4-angled *Bidens* (34)
7. Plants polygamo-monoecious, having heads with marginal flowers differing from the inner (the marginal pistillate, either sterile or fertile,* and the inner bisexual, either sterile or fertile).
20. Receptacles of heads bristly; marginal flowers of the heads sterile.
21. Heads subtended by foliaceous bracts; leaves spiny-toothed; corollas of the marginal flowers shorter than those of the inner.....*Cnicus* (50)
21. Heads not subtended by foliaceous bracts; leaves not spiny-toothed; corollas of the marginal flowers much larger and more conspicuous than those of the inner, the heads thus seemingly radiate.....*Centaurea* (49)
20. Receptacles of the heads naked; marginal flowers of the heads fertile.
22. Involucre long-cylindrical, the principal phyllaries in one series, a few much reduced bracts at the base; pappus of copious, soft, white bristles *Erechtites* (44)
22. Involucre turbinate to hemispheric, the phyllaries closely imbricated in several series; pappus of several comparatively stiff bristles.
23. Corollas white; phyllaries all scarious although sometimes purplish; plants not emitting a strong camphoric odor; stems and leaves usually woolly-pubescent; receptacles of the heads alveolate; achenes terete or slightly flattened, not ribbed.....*Gnaphalium* (17)

* The fertility of the ray *vs.* the disk flowers can usually be determined even before maturity by an examination and comparison of their ovularies and the exercise of some judgment as to their relative degree of development.

23. Corollas purplish; outer phyllaries herbaceous, the inner scarious, both often purplish; plants emitting a strong, unpleasant, distinctly camphoric odor; stems and leaves not woolly, stems, at least, glandular-puberulent; receptacles of the heads naked; achenes 5-angled.....*Pluchea* (15)

6. Heads radiate (the marginal flowers with distinctly ligulate corollas (rays), the inner with tubular corollas (disk flowers).

24. Rays yellow, or dull-rose purple (in one genus only).

25. Pappus all, or in part at least, of capillary bristles.

26. Pappus wholly of capillary bristles.

27. Principal phyllaries all of equal length and in 2 series in a bell-shaped involucre, or in 1 series in a cylindrical involucre with a few much reduced bracteoles at the base.

28. Leaves opposite, the larger ones basal, the inflorescence essentially scapose; pappus of scabrous capillary bristles; phyllaries in 2 series in a bell-shaped involucre.....*Arnica* (43)

28. Leaves alternate, cauline; pappus of copious soft capillary bristles; phyllaries in 1 series forming a cylindrical involucre with bracteoles at the base.....*Senecio* (46)

27. Phyllaries unequal, imbricated in several series.

29. Annuals; inflorescence an open panicle (with solitary heads on divergent branches); receptacles of the heads alveolate *Haplopappus* (9)

29. Perennials; inflorescence of numerous heads crowded in thyrsoid-, racemose-, or racemose-secund panicles; receptacles of the heads naked, not alveolate.....*Solidago* (10)

26. Pappus of an outer series of very short small scales and an inner series of capillary bristles.....*Chrysopsis* (8)

25. Pappus not even in part of capillary bristles, either crown-like, or of a few scales, or of awns or teeth, or none.

30. Phyllaries in a single series.

31. Phyllaries in one series and united except at the very tips so that the involucre is in the form of a tube.....*Tagetes* (39)

31. Phyllaries in a single series, but not united.....*Madia* (37)

30. Phyllaries in more than one series.

32. Ray flowers fertile, disk flowers sterile.

33. Achenes not obcompressed, i.e., flattened parallel to the phyllaries.

34. Achenes partially enclosed by the inner unarmed phyllaries *Polymnia* (18)

34. Achenes closely surrounded by the prickly inner phyllaries *Acanthospermum* (19)

33. Achenes obcompressed, i.e., flattened parallel to the phyllaries.

35. Achenes 4-angled; rays 5-6; low herbs flowering in spring *Chrysogonum* (21)

35. Achenes winged; rays numerous, tall coarse herbs flowering in summer and autumn.....*Silphium* (20)

32. Ray flowers sterile and disk flowers fertile, or both fertile.

36. Ray flowers sterile and disk flowers fertile.

37. Stem conspicuously winged; rays irregularly disposed about the margin of the heads.....*Actinomeris* (31)

37. Stems not winged; rays regularly disposed about the margin of the heads.

38. Rays dull rose-purple; receptacles of the heads conical; chaff longer than the disk flowers.....*Brauneria* (29)
38. Rays yellow; receptacles of the heads flat or convex; chaff not longer than the disk flowers.
39. Phyllaries all of the same type and imbricated.
40. Pappus deciduous, composed of 2 thin scales on the angles of the achenes, sometimes with intermediate smaller scales *Helianthus* (30)
40. Pappus none, or a low crown.....*Rudbeckia* (28)
39. Phyllaries in two distinct series, the outer foliaceous, the inner nearly membranaceous.
40. Pappus awns barbed.....*Bidens* (34)
40. Pappus awns, if present, not barbed.....*Coreopsis* (33)
36. Ray flowers and disk flowers both fertile.
41. Pappus of 1–3 awns or teeth.....*Verbesina* (32)
41. Pappus none.
42. Phyllaries nearly equal in 2–3 rows; leaves long-petioled...*Heliopsis* (25)
42. Phyllaries of 2 series, an outer composed of 4 foliaceous bracts united at the base to form a 4-angled cup, and an inner of smaller chaffy bracts; leaves sessile or connate.....*Tetragonotheca* (27)
24. Rays white, or varying from pink to lavender or purple.
43. Pappus of capillary bristles.
44. Corollas of *disk* flowers white or stramineous; rays few, usually 4–6 *Sericocarpus* (13)
44. Corollas of *disk* flowers yellow, red, brown, or purple; rays numerous.
45. Phyllaries nearly equal and scarcely imbricated; receptacles of the heads naked, not alveolate.....*Erigeron* (12)
45. Phyllaries unequal and imbricated in several series; receptacles of heads alveolate.....*Aster* (11)
43. Pappus of chaffy scales, or a crown, or none.
46. Receptacles of the heads naked.....*Chrysanthemum* (42)
46. Receptacles of the heads chaffy.
47. Ray flowers and disk flowers both fertile.
48. Leaves opposite.
49. Phyllaries 10–12 in 2 series; receptacles of the heads flat; leaves sessile, of a lanceolate type.....*Eclipta* (26)
49. Phyllaries 4–5; receptacles of the heads conical; leaves petioled, of an ovate type.....*Galinsoga* (36)
48. Leaves alternate.
50. Achenes flattened, callous-margined; rays short and broad *Achillea* (40)
50. Achenes terete, ribbed; rays longer than broad.....*Anthemis* (41)
47. Ray flowers fertile, disk flowers not fertile.....*Parthenium* (22)
1. All flowers of the head with ligulate corollas.
51. Pappus composed entirely of capillary bristles.
52. Pappus bristles plumose.....*Hypochaeris* (53)
52. Pappus bristles not plumose, smooth, scabrous, or with short barbellate setae.
53. Phyllaries in 1 series of equal bracts.....*Crepis* (58)
53. Phyllaries in more than one series.
54. Achenes not flattened, either columnar or fusiform.
55. At maturity, the hypanthium extended beyond the body of the achene in the form of a long beak.

56. Pappus soft-white; heads solitary on a hollow scape *Taraxacum* (54)
56. Pappus reddish, or rust-colored; heads solitary on a branched scape, or on a branched, leafy stem.....*Pyrrhopappus* (57)
55. At maturity, the hypanthium not extended beyond the body of the achene in the form of a long beak.
57. Phyllaries in 2 series, long linear ones in an inner row, and short bracteoles at the base; heads nodding.....*Prenanthes* (59)
57. Phyllaries unequal and imbricated; heads erect..*Hieracium* (60)
54. Achenes flattened.
58. Achenes truncate at the apex, not appreciably narrowed from the middle; heads many-flowered, 50 or more flowers in each; heads at maturity swollen at the base.....*Sonchus* (55)
58. Achenes narrowed at the apex, usually beaked; heads with 30 or fewer flowers in each; heads at maturity not swollen at the base *Lactuca* (56)

51. Pappus of scales, or of scales and bristles.
59. Pappus of a crown of scales; phyllaries in 2 series; rays blue or rose *Cichorium* (51)
59. Pappus of scales and bristles; phyllaries in 1 series; rays yellow or orange *Krigia* (52)

CATALOGUE OF THE SPECIES AND VARIETIES WITH KEYS

1. *Vernonia* Schreb. Ironweed

a. Phyllaries with long filiform tips; pappus purple or purplish; leaves lanceolate to lance-oblong, the blades tapering to both ends.....1. *V. novaboracensis*
a. Phyllaries tipped by short awns; pappus stramineous; leaves broadly ovate-lanceolate, abruptly contracted below the middle to a winged petiolar portion..2. *V. glauca*

1. *V. novaboracensis* Willd. Frequent. Low, wet pastures, seepage slopes, and wet thickets. Late summer and autumn.

2. *V. glauca* (L.) Willd. Frequent. Pine woods, dry oak-hickory slopes, dry thickets, and grass-weed borders. Some specimens of this species have phyllaries with filiform tips. To these the name **V. glauca* forma *longiaristata* Fern. (1941) has been given. Late summer and autumn.

2. *Elephantopus* (Vaill.) L. Elephant's Foot

a. Leaves mostly cauline and all of the same type.....1. *E. carolinianus*
a. Leaves chiefly basal; inflorescence scapose with a few bract-like leaves subtending the inflorescence branches.
b. Leaves and stems densely tomentose; longest phyllaries up to 1.4 cm. long; achenes 4–5 mm. long; pappus bristles 7–8 mm. long.....2. *E. tomentosus*
b. Leaves and stems strigose-puberulent; longest phyllaries not exceeding 8 mm. long; achenes 3 mm. long; pappus bristles 4 mm. long.....3. *E. nudatus*

1. *E. carolinianus* Raeuschel. Frequent. Moist cut-over woodlands, stream bank woods, and in weed thickets of disturbed areas. Late summer and autumn.

2. *E. tomentosus* Willd. Frequent. Pine woods, dry-cut-over woodlands, and in pastures. Late summer and autumn.

3. *E. nudatus* A. Gray. A coastal plain plant known in our area from a single

locality in Wake County, a bog at Method just west of Raleigh.* Late summer and autumn.

3. *Eupatorium* (Tourn.) L.

a. Leaves verticillate†; heads purple.
  b. Leaves lanceolate to oval, tapering at the base, pinnately-veined; stem not purple-specked.
    c. Stems hollow, purple, glaucous; leaves in 4's to 6's, with blunt teeth; florets scarcely exserted from the involucre; corolla 3.5–4.8 mm. long ..... 1. *E. fistulosum*
    c. Stems solid, green with purple nodes, faintly glaucous; leaves in 3's to 4's, rarely 2's or 5's, sharply toothed; florets much exserted from the involucre; corollas 5.5–7.5 mm. long ..... 2. *E. purpureum*
  b. Leaves ovate to ovate-lanceolate, abruptly contracted into the petiole, more or less 3-nerved; stem purple-specked ..... 3. *E. dubium*
a. Leaves opposite, or the upper ones alternate (occasionally 3 at a node, but if so the heads not purple); heads white, whitish, or blue or violet.
  d. Leaves connate-perfoliate or connate-clasping.
    e. Leaves broad at the bases and connate-perfoliate ..... 4. *E. perfoliatum*
    e. Leaves narrowed at the base and connate-clasping ..... 5. *E. cuneatum*
  d. Leaves not either connate-perfoliate or connate-clasping, either sessile or petioled.
    f. Leaf blades dissected or pinnatifid, the segments filiform..6. *E. capillifolium*
    f. Leaf blades entire, toothed, or incised, but definitely not pinnatifid.
      g. Leaf blades petioled, or only a part of them sessile.
        h. Heads blue or violet ..... 7. *E. coelestinum*
        h. Heads white or whitish.
          i. Phyllaries unequal, the outer much shorter than the inner, and imbricated ..... 8. *E. serotinum*
          i. Phyllaries nearly equal, a few outer ones but little shorter than the inner, and not giving the involucre an imbricated appearance.
            j. Leaves crenate; middle cauline leaves largest and petioled, smaller cauline leaves near the base and the top of the plant and sessile ..... 9. *E. aromaticum*
            j. Leaves serrate; all petioled, the largest at the base of the plant and diminishing in size upward ..... 10. *E. rugosum*
      g. Leaf blades all sessile.
        k. Leaves lanceolate, elliptic, or varying to ovate or suborbicular.
          l. Plants glabrous, or pubescent only in the inflorescence; leaves ovate-lanceolate, gradually tapering from the broadly cuneate base to an acute or acuminate tip ..... 11. *E. sessilifolium*
          l. Plants pubescent throughout.
            m. Leaves of a lanceolate or elliptic-lanceolate type.

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* See Fox, William B., and R. K. Godfrey, "Notes on Plant Distribution in North Carolina. I." Rhodora **51**: 129–146, for reports of several other coastal plain plants from this locality.

† Key to the three species of purple verticillate *Eupatoria* adapted from Wiegand, Rhodora **22**: 62. 1920.

n. Leaves strongly three-nerved, not conspicuously reticulate-veined between, entire or remotely toothed above the middle; phyllaries obtuse, glandless
12. *E. altissimum*

n. Leaves obscurely three-nerved, conspicuously veined between, coarsely toothed from near the base; phyllaries acute, glandular
13. *E. album*, var. *glandulosum*

m. Leaves of an ovate type.

o. Leaves ovate-lanceolate, much longer than broad, crenate-dentate to coarsely but bluntly toothed; inflorescence branches generally alternate
14. *E. pilosum*

o. Leaves of a broadly ovate type, nearly as broad as long; inflorescence branches generally opposite and numerous, forming a broad compound corymb.

p. Leaf blades having the main lateral veins arising with the midvein at the base of the blade, often all three principal veins running parallel for a short distance.....15. *E. rotundifolium*

p. Leaf blades having the main lateral veins arising from the midvein well above the base of the blade.

q. Leaf blades cuneate or at most sub-truncate at the base
16. *E. pubescens*

q. Leaf blades sub-cordate to broadly truncate at the base
17. *E. cordigerum*

k. Leaves linear-lanceolate to narrowly linear.

r. Phyllaries with attenuate scarious tips; leaves lanceolate to linear-lanceolate, serrate; stem slender, usually simple to the inflorescence....18. *E. leucolepis*

r. Phyllaries with obtuse or rounded tips; leaves narrowly lanceolate to linear or linear-filiform, entire; stem usually much branched.

s. Heads about 5 mm. high; pappus 4 mm. high; leaves narrowly linear to linear-filiform.....19. *E. hyssopifolium*

s. Heads about 7 mm. high; pappus 6 mm. high; leaves narrowly lanceolate to oblanceolate, twisted at the base so that the flat surfaces are oriented vertically to the ground.....20. *E. linearifolium*

1. *E. fistulosum* Barratt.* Frequent. Moist, tall weed thickets, seepage slopes, open stream banks. Late summer and early autumn.

2. *E. purpureum* L. Infrequent. Woods and thickets. Late summer and autumn.

3. *E. dubium* Willd. Confined in our area to the coastal plain portion of Wake County where frequent in similar habitats to *E. fistulosum*. Late summer and autumn.

4. *E. perfoliatum* L. Frequent. Wet pastures, seepage slopes, and along the banks of small streams, either in woods or open fields. Late summer and autumn.

5. *E. cuneatum* Engelm. Included on the basis of a single specimen collected many years ago by Dr. W. C. Coker in Orange County.

6. *E. capillifolium* (Lam.) Small. Frequent. Lowland old fields and pastures. Autumn.

* No attempt is made here to relate the names *E. fistulosum* Barratt, *E. purpureum* L., and *E. dubium* Willd. to names for verticillate *Eupatoria* in Small's Manual. For a discussion of the nomenclature of this group see Wiegand and Weatherby, Rhodora **39**: 297–306. 1937.

7. *E. coelestinum* L. Infrequent. Lowland pastures and moist, open woods. Autumn.

8. *E. serotinum* Michx. Occasional. Moist tall weed thickets, the more moist pine and cut-over woods, or edges of wet woodlands. Late summer and autumn.

9. *E. aromaticum* L. Frequent. Pine, oak-hickory, and cut-over woods. Autumn.

10. *E. rugosum* Houtt. (*E. urticaefolium* Reichard.) Rare. Wet floodplain woodland. In the area known from a single locality in Wake County. The specimen corresponds to *E. rugosum* forma *villicaule* Fern. (See Fernald, Rhodora 44: 463. 1942).

11. *E. sessilifolium* L. Rare. Open pine woodland. Included on the basis of a single record from Wake County. The specimen corresponds to *E. sessilifolium* var. *Vaseyi* (Porter) Fern. and Grisc. (See Fernald and Griscom, Rhodora 37: 180. 1935.)

12. *E. altissimum* L. Rare. Roadside grass-weed border. Based on one record from Wake County. Late summer and autumn.

13. *E. album* L., var. *glandulosum* (Michx.) Fern. Frequent. Pine and oak-hickory woods. Late summer and autumn.

14. *E. pilosum* Walt. (*E. verbenaefolium* Michx.) Frequent. Bogs, open pine woods, and grass-weed borders. Late summer and autumn.

15. *E. rotundifolium* L. Frequent. Pine woods, bogs, seepage slopes, and old fields. Late summer and autumn.

16. *E. pubescens* Muhl. Occasional. Dry pine, oak-hickory, and cut-over woods. Late summer and autumn.

17. * *E. cordigerum* Fern. (1945). In the area known only in Wake County where there are several stations for it. Bogs, wet thickets, and moist pockets in pine woods. Late summer and autumn.

18. *E. leucolepis* (DC) T. & G. Known in the area in but one locality in Wake County, the bog at Method just west of Raleigh. Late summer and autumn.

19. *E. hyssopifolium* L. Frequent. Open pine, oak-hickory, and cut-over woods, old fields, and grass-weed borders. Late summer and autumn.

20. *E. linearifolium* Walt. (*E. tortifolium* Chapm.) Confined to the coastal plain portion of Wake County. Sandy old fields, open pine woods, and grass-weed borders. Late summer and autumn.

4. *Mikania* Willd. Climbing Hempweed

M. scandens (L.) Willd. Frequent. Moist tall weed thickets, and borders of wet woods. Late summer and autumn.

5. *Kuhnia* L.

K. eupatorioides L. Infrequent. Open pine woods. Autumn.

6. *Carphephorus* Cass.

C. bellidifolius (Michx.) T. & G. Frequent. Open pine and cut-over woods, and grass-weed borders. Late summer and autumn.

7. *Liatris* Schreb. Blazing Stars

a. Pappus plumose ..... 1. *L. squarrosa*
a. Pappus barbellate.
b. Phyllaries acute to acuminate, the mid-veins distinct and forming a rigid keel
2. *L. regimontis*
b. Phyllaries obtuse to broadly rounded, the mid-veins not distinct.
c. Leaves linear; heads small (not over 1 cm. broad) ..... 3. *L. graminifolia*
c. Leaves lanceolate to oblanceolate or obovate; heads large (about 1.5 cm. broad)
4. *L. scariosa*, var. *squarrulosa*

1. *L. squarrosa* (L.) Michx. Infrequent. Open pine woods and grass-weed borders. Summer.

2. *L. regimontis* (Small) K. Sch. Gaiser (1946) cites one specimen from Wake County. Late summer and autumn.

3. *L. graminifolia* (Walt.) Willd. Common. Open pine woods, grass-weed borders, and occasional in oak-hickory woods. Late summer and autumn.

4. *L. scariosa* (L.) Willd., var. *squarrulosa* (Michx.) Gray. Infrequent. Grass-weed borders and open woods. Late summer and autumn.

8. *Chrysopsis* Nutt. Golden Aster

a. Leaves narrowly lanceolate or linear, grass-like, the principal veins parallel.*
b. Plants with prolonged flagelliform or filiform stolons and eventual slender rhizomes.
c. Involucre pilose to silky-lanate, phyllaries and peduncles not glandular
1. *C. nervosa* var. *stenolepis*
c. Involucre not pilose or silky-lanate, phyllaries and peduncles glandular
2. *C. adenolepis*
b. Plants cespitose or tufted, the basal offsets erect or at most short and promptly assurgent stolons ..... 3. *C. graminifolia*
a. Leaves lanceolate to elliptic-lanceolate or oblanceolate, definitely not grass-like.
d. Stems simple and erect, or if branched at the base, the branches erect; stems and leaves with a sparse long-villosity; lower cauline leaves much larger than the upper and narrowed to definite winged petioles ..... 4. *C. mariana*
d. Stems much branched from a crown, the branches decumbent; stems and leaves rather densely and uniformly white cottony-lanate; lower cauline leaves essentially like the upper and all sessile ..... 5. *C. gossypina*

1. *C. nervosa* (Willd.) Fern., var. *stenolepis* Fern. (*Pityopsis graminifolia* (Michx.) Nutt. *sensu* Small). Rare. Included here on the basis of one specimen cited by Fernald (1942). It was from the coastal plain portion of Wake County at McCullers. Late summer.

2. * *C. adenolepis* Fern. (1942). Rare. Grass-weed borders, open woods. Late summer and autumn.

3. *C. graminifolia* (Michx.) Ell. (*Pityopsis aspera* (Shuttlw.) Small). Frequent. Open pine woods, grass-weed borders, occasionally in oak-hickory woods. Summer and autumn.

* Key to the linear-leaved *Chrysopsis* adapted from Fernald in Rhodora **44:** 468. 1942.

4. *C. mariana* (L.) Nutt. Frequent. Pine woods, grass-weed borders, and occasionally in oak-hickory woods. Summer and autumn.

5. *C. gossypina* (Michx.) Nutt. (*C. pilosa* (Walt.) Britton *sensu* Small; includes *C. gossypina*, forma *decumbens* (Chapm.) Godfrey). Confined in the area to sandy ridges in the coastal plain section of Wake County. Late summer and autumn.

9. *Haplopappus* Endl.

H. divaricatus (Nutt.) Gray (*Isopappus divaricatus* (Nutt.) T. & G.). In the area, frequent only in Wake County. Old fields and grass-weed borders. Autumn.

10. *Solidago* L.—Goldenrods

a. Leaves narrowly linear to linear-filiform; inflorescence corymbose and more or less flat-topped ..... 1. *S. microcephala*
a. Leaves not narrowly linear, broader; inflorescence paniculate.
  b. Heads not unilaterally arranged on the inflorescence branches (not secund), inflorescence thyrsiform.
    c. Heads white or cream colored ..... 2. *S. bicolor*
    c. Heads yellow
      d. Plants having no basal rosettes of leaves.
        e. Plants pubescent throughout; involucre squarrose; median cauline leaves larger than either the lowermost or the uppermost ..... 3. *S. petiolaris*
        e. Plants glabrous at least below; involucre not squarrose; larger cauline leaves lowermost and gradually diminishing in size upwards.
          f. Plants glabrous throughout; leaves sharply serrate, thin; inflorescence not terminal, the lower clusters of heads in the axils of ordinary cauline leaves ..... 4. *S. caesia*
          f. Plants glabrous below, hirsutulous in the inflorescence; leaves entire, coriaceous; inflorescence a large terminal thyrse ..... 5. *S. speciosa*
      d. Plants having conspicuous basal rosettes of leaves.
        g. Stems puberulent throughout; phyllaries acute to acuminate .. 6. *S. puberula*
        g. Stems glabrous below, puberulent in the inflorescence; phyllaries obtuse or rounded at the tips ..... 7. *S. erecta*
  b. Heads unilaterally arranged on the inflorescence branches (secund), inflorescence a terminal spreading panicle.
    h. Plants not having long, horizontal stolons.
      i. Stems sharply angled; lower cauline leaves mostly about 1.5 dm. long and about 5–7 cm. wide, the blades gradually narrowed into a winged petiole which is decurrent on the stem ..... 8. *S. salicina*
      i. Stems not sharply angled; lower cauline leaves mostly shorter, if up to 1.5 dm. long then not over 3 cm. wide; petioles if winged, not decurrent.
        j. Leaves all entire and sessile, no basal rosettes of petioled leaves, leaves pellucid-dotted, sweet-scented ..... 9. *S. odora*
        j. Leaves, some at least, toothed, the lower cauline sometimes narrowed to winged petioles, basal rosettes of petioled leaves present, leaves not pellucid-dotted nor sweet-scented.
          k. Stems ashy-whitish with a short puberulence throughout 10. *S. nemoralis*
          k. Stems glabrous at least below.

l. Stems glabrous throughout; rosette and lower cauline leaf blades lanceolate to oblanceolate, the upper cauline much reduced, linear-filiform; involucres 4–5 mm. high.....11. *S. pinetorum*

l. Stems glabrous below, pubescent in the inflorescence; rosette leaf blades oval-ovate, abruptly contracted below the middle, the upper cauline gradually reduced, elliptic-lanceolate; involucres 6–7 mm. high.

m. Achenes 2 mm. long, ribbed, clavate.....12. *S. Boottii*

m. Achenes 3 mm. long, ribbed, fusiform.....13. *S. yadkinensis*

h. Plants with long, horizontal stolons, the plants thus usually occurring in colonies.

n. Leaves more or less plainly 3-ribbed, that is, two of the lateral veins prominent and parallel with the mid-rib.

o. Stems puberulent throughout; leaves entire or only remotely toothed, scabrous above, minutely pubescent over the entire under surfaces 14. *S. altissima*

o. Stems glabrous, often glaucous below; leaves sharply though minutely serrate to entire, scabrous above, hirsutulous on the veins beneath 15. *S. gigantea*

n. Leaves not three-ribbed, prominently pinnately veined, sharply serrate.

p. Stems glabrous below, pubescent on the inflorescence branches; leaves smooth to slightly hispid above, pubescent on the veins below 16. *S. rugosa*, var. *sphagnophila*

p. Stems puberulent throughout; leaves rough above, pubescent over the entire under surfaces.

q. Panicle pyramidal, the branches floriferous throughout, or only the lower branches leafy-bracted below.....17. *S. rugosa*, var. *aspera*

q. Panicle lax with few distant and prolonged and divergent branches floriferous above the middle.....18. *S. rugosa*, var. *celtidifolia*

1. *S. microcephala* (Greene) Bush. (*S. minor* (Michx.) Fern; *Euthamia minor* (Michx.) Greene). Flat-topped Goldenrod. Common. Broom sedge old fields, open pine woods, and grass-weed borders. Late summer and autumn.

2. *S. bicolor* L. White Goldenrod. Frequent. Open pine woods, cut-over woodlands; occasional in oak-hickory woods; rarely in grass-weed borders. Late summer and autumn.

3. *S. petiolaris* Ait. (*S. Milleriana* Mackenzie). Infrequent. Open pine woods, open oak-hickory woods. Late summer and autumn.

4. *S. caesia* L. Frequent. Oak-hickory or beech maple woods, and stream bank woods. Late summer and autumn.

5. *S. speciosa* Nutt. Infrequent. Grass-weed borders, open pine woods. Autumn.

6. *S. puberula* Nutt. Occasional. Open pine woods and grass-weed borders. Late summer and autumn.

7. *S. erecta* Pursh. Frequent. Open pine woods, cut-over woodlands, and occasional in grass-weed borders. Late summer and autumn.

8. *S. salicina* Ell. Infrequent. Wet woodlands, seepage slopes, and very moist tall weed thickets. Autumn.

9. *S. odora* Ait. Sweet-scented Goldenrod. Frequent. Open pine woods, grass-weed borders; occasional in the broomsedge old fields and open oak-hickory woods. Late summer and early autumn.

10. *S. nemoralis* Ait. Frequent. Broom sedge old fields, open pine woods, and grass-weed borders. Late summer and autumn.

11. *S. pinetorum* Small. Frequent. Broom sedge old fields, open pine woods, grass-weed borders, and occasional in the oak-hickory woods. Summer. This species is commonly misidentified as *S. juncea* Ait. which is generally more northern.

12. *S. Boottii* Hook. Occasional. Cut-over woods, grass-weed borders, and open pine woods. Late summer and autumn.

13. *S. yadkinensis* (Porter) Small. Occasional. Cut-over woods, and open pine woods. Late summer and autumn.

14. *S. altissima* L. (*S. hirsutissima sensu* Small). A dominant tall weed of the old fields; frequent in dry tall weed thickets. Late summer and autumn.

15. *S. gigantea* Ait. (*S. serotina* Retz. *sensu* Small). Frequent. Moist tall weed thickets. Late summer and autumn.

16. *S. rugosa* Mill., var. *sphagnophila* Graves. (*S. altissima sensu* Small is *S. rugosa* Mill.) Frequent. Wet woods, seepage slopes, and moist tall weed thickets. Late summer and autumn.

17. *S. rugosa* Mill., var. *aspera* (Ait.) Fern. Frequent. Tall weed thickets, and open stream bank woods. Late summer and autumn.

18. *S. rugosa* Mill., var. *celtidifolia* (Small) Fern. Frequent. Tall weed thickets, and stream bank woods. Late summer and autumn.

These three varieties of the more northern *S. rugosa* intergrade so that it is frequently difficult to relegate a given specimen definitely to one of the above categories.

11. *Aster* (Tourn.) L.

a. Basal and lower cauline leaf blades cordate or abruptly narrowed at the base of the blades, petioled.
  b. Petioles of basal and lower cauline leaves not at all winged; leaf blades sharply serrate; rays white ..... 1. *A. divaricatus*
  b. Petioles of the lowermost leaves fairly distinct, becoming progressively shorter and more winged upward; rays bluish.
    c. Stems puberulent throughout; bases of the petioles expanded and clasping; leaves scabrous above, hirsutulous below, entire or with wavy margins; inflorescence a loose, open panicle ..... 2. *A. undulatus*
    c. Stems glabrous below, sparingly pubescent in the inflorescence; petiolar bases not expanded and clasping; leaves pubescent above, glabrate below, serrate; inflorescence a relatively dense panicle with ascending branches. 3. *A. sagittifolius*
a. Basal and lower cauline leaf blades not cordate, gradually narrowed at the bases, sessile or petioled.
  d. Pappus double, of an outer series of short, rigid bristles, and an inner of longer capillary bristles; inflorescence cymose.
    e. Cauline leaves short, all about equal (about 2-4 cm. long), linear-oblong, rigid-coriaceous, prominently 1-nerved, with revolute margins; peduncles with stiff, ascending, subulate bracts grading into the phyllaries of the involucres; inner pappus bristles not thickened at the tips; rays blue ..... 4. *A. linariifolius*
    e. Cauline leaves much larger and broader, lanceolate to ovate or obovate, not coriaceous; peduncles naked; inner pappus bristles with thickened tips; rays white 5. *A. infirmus*

d. Pappus simple, of one series of capillary bristles.
f. Rays blue or violet.
g. Stems tall, virgate; heads in elongate racemes or erect-racemose panicles; leaves silvery-silky on both surfaces.....6. *A. concolor*
g. Stems not tall and virgate; heads in open panicles or in cymes; leaves not silvery-silky.
h. Stems pubescent throughout.
i. Involucre squarrose; lower cauline leaves sessile or blades narrowed into petioles, but not clasping.
j. Leaves all sessile; stems high and diffusely branched forming an open paniculate inflorescence with solitary heads terminating the branches
7. *A. grandiflorus*
j. Lower cauline leaves wing-petioled; stems relatively low and slender, bearing a terminal cyme of short-pedicellate heads.
k. Involucre campanulate to hemispheric; phyllaries glandular-pubescent; rays numerous, three-fourths of an inch long or longer
8. *A. spectabilis*
k. Involucre turbinate; phyllaries glabrous on the backs, ciliate on the margins; rays few (9–12), one-quarter to one-half inch long
9. *A. gracilis*
i. Involucre not squarrose; lower cauline leaves clasping by broad truncate or auriculate bases.
l. Stems coarse, reddish, hispid in lines with short, thick, tubercular-based hairs; leaves truncate-clasping; phyllaries not glandular, only slightly pubescent.....10. *A. puniceus*
l. Stems slender, puberulent; leaves auriculate-clasping; phyllaries glandular-pubescent.....11. *A. patens*
h. Stems glabrous throughout.
m. Phyllaries all appressed erect; lower cauline leaves lanceolate to oblanceolate with the blades narrowed into winged petioles
12. *A. laevis*
m. Phyllaries spreading at the tips; leaves all linear, rigid
13. *A. novi-belgii*, var. *elodes*
f. Rays white (sometimes becoming purplish in older heads).
n. Stems simple, zigzagged; heads in a terminal cyme.....14. *A. acuminatus*
n. Stems branched, the inflorescence a diffuse panicle, not zigzagged.
o. Inner phyllaries slenderly and sharply pointed, not dilated at the apices, tending to become inrolled at the tips.
p. Stems villous throughout; lower cauline leaves lanceolate or oblanceolate
15. *A. pilosus*
p. Stems glabrous or sparsely villous; lower cauline leaves narrowly lanceolate or linear.....16. *A. pilosus*, var. *demotus*
o. Inner phyllaries broadly and bluntly pointed, dilated at the apices, not inrolled at the tips.
q. Lower cauline leaves elongate, linear-lanceolate to linear, not tapering much from the middle, rigid-coriaceous and revolute; upper cauline leaves conspicuously reduced, bract-like, and numerous, the heads being borne singly at the ends of ascending or divergent bracteate peduncles.....17. *A. dumosus*, var. *coridifolius*
q. Lower cauline leaves linear-lanceolate to elliptic or oblanceolate, tapering from a broader middle portion to both ends, not particularly rigid, the cauline leaves gradually diminishing in size upward, and the peduncles of the heads not with many equal bracteate leaves.

r. Cauline leaves linear to linear-lanceolate, only slightly narrowed from the middle to either end.....18. *A. vimineus*
r. Cauline leaves lanceolate to elliptic or oblanceolate, acuminate at both ends.
s. Heads more than 10 mm. broad; disk flowers not purplish; stems essentially glabrous.....19. *A. simplex*
s. Heads less than 10 mm. broad; disk flowers purplish; stems puberulent, becoming glabrate below.....20. *A. lateriflorus*

1. *A. divaricatus* L. Frequent. Beech-maple and stream bank woods. Autumn.

2. *A. undulatus* L. Frequent. Grass-weed borders, open pine woods, dry cut-over woods, and occasionally in oak-hickory woods. Autumn.

3. *A. sagittifolius* Willd. Infrequent. Tall weed thickets. Autumn.

4. *A. linariifolius* L. (*Ionactis linariifolius* (L.) Greene). Frequent. Grass-weed borders and open pine woods. Autumn.

5. *A. infirmus* Michx. (*Doellingeria infirmus* (Michx.) Greene). Infrequent. Oak-hickory, beech-maple, and stream bank woods. Late summer and autumn.

6. *A. concolor* L. Frequent. Grass-weed borders, open pine woods, broom sedge old fields. Autumn.

7. *A. grandiflorus* L. Frequent. Grass-weed borders, open pine woods, dry cut-over woods. Autumn.

8. *A. spectabilis* Ait. Rare. Collections of this species are from Durham County only. Autumn.

9. *A. gracilis* Nutt. Rare. Known from one station in Durham and one in Wake County. Autumn.

10. *A. puniceus* L. Occasional. Moist tall weed thickets. The plant which occurs in the area is probably identifiable with *A. puniceus* L., var. *firmus* (Nees) T. & G., forma *lucidulus* (Gray) Fernald.* Autumn.

11. *A. patens* Ait. Frequent. Grass-weed borders, open pine woods, dry cut-over woods, and occasional in oak-hickory and stream bank woods. Autumn.

12. *A. laevis* L. Infrequent. Grass-weed borders and open pine woods. Autumn.

13. *A. novi-belgii* L., var. *elodes* (T. & G.) Gray. Infrequent. Moist tall weed thickets. Autumn.

14. *A. acuminatus* Michx. Rare. Based on one collection from Orange County.

15. *A. pilosus* Willd. Frequent. Grass-weed borders and cut-over woodlands. A dominant in the tall weed stage of the old field succession. Autumn.

16. *A. pilosus* Willd., var. *demotus* Blake. (*A. ericoides* of many authors, probably *A. ramosissimus* Mill. in Small.) Frequent. Habitat as for the species, but confined to the more sterile soils. Autumn.

17. *A. dumosus* L., var. *coridifolius* (Michx.) T. & G. Frequent. Grass-weed borders, open pine woods, and occasionally in oak-hickory woods. Autumn. Many plants included here are as described for *A. dumosus*, var. *subulaefolius* T. & G., but the two grade imperceptibly into each other.

* See Fernald in Rhodora 51: 95. 1949.

18. *A. vimineus* Lam. Occasional. Wet woods, stream bank woods, and moist tall weed thickets. Autumn.

19. *A. simplex* Willd. Occasional. Wet woods, open stream bank clearings. Autumn.

20. *A. lateriflorus* (L.) Britton. Frequent. Wet woods, stream bank woods, moist tall weed thickets, and beech-maple woods. Autumn.

12. *Erigeron* L.

a. Rays inconspicuous, scarcely longer than the pappus; inflorescence an elongate diffuse panicle of very small heads.....1. *E. canadensis*
a. Rays conspicuous, much exceeding the pappus; inflorescence of a few large heads on slender peduncles, or a cyme of smaller heads.
  b. Perennials; pappus of a single series of bristles.
    c. Principal leaves low on the stem or basal, obovate to broadly spatulate; rays linear, lilac to bluish-purple; heads large (up to 3 cm. broad) and few on a scape 2. *E. pulchellus*
    c. Principal leaves cauline, spatulate; rays very narrow, linear-filiform, roseate to rose-purple; heads smaller (not over 2.5 cm. broad) and several to numerous in a terminal cyme.....3. *E. philadelphicus*
  b. Annuals or biennials; pappus double, of an outer series of scales and an inner series of deciduous bristles (usually absent in the ray flowers).
    d. Stem pubescent with long, spreading hairs; cauline leaves ovate to oblanceolate, coarsely serrate; phyllaries shallowly serrate or entire; phyllaries with minute pubescence.....4. *E. annuus*
    d. Stem pubescent with short, appressed-ascending hairs; cauline leaves lanceolate to narrowly oblanceolate or spatulate; shallowly serrate or entire; phyllaries with minute pubescence.....5. *E. ramosus*

1. *E. canadensis* L. (*Leptilon canadense* (L.) Britton) Horseweed. Frequently dominant in the tall weed stages of the old field succession just following the grass stage and before *Aster pilosus* becomes the dominant. Summer and early autumn.

2. *E. pulchellus* Michx. Robin's Plantain. Occasional. Open stream bank woods, lowland cut-over woodlands, moist open banks, and in open seepage slopes. Spring.

3. *E. philadelphicus* L. Rare. Based on a single collection from Durham County. Spring.

4. *E. annuus* (L.) Pers. Daisy Fleabane or Mayweed. Frequent in the late spring aspect of the old fields the year following cultivation; frequent also in the grass-weed borders. Late spring and early summer.

5. *E. ramosus* (Walt.) B.S.P. White-top. Frequent in similar situations to number 4. Late spring and early summer.

13. *Sericocarpus* Nees. Ragged Asters

a. Stem glabrous throughout; leaves linear.....1. *S. linifolius*
a. Stem pubescent throughout; leaves broader, obovate, oblanceolate, or elliptic.
  b. Lower cauline leaves from 5–15 cm. long, the blades constricted into winged petioles,

gradually diminishing in size upward, serrate, the upper oblanceolate to elliptic; tips of the outer phyllaries spreading or recurved.....2. *S. asteroides*

b. Lower cauline leaves about 2–3 cm. long, obovate, sessile, diminishing little in size upward, entire, the upper short-elliptic; tips of all the phyllaries erect
3. *S. bifoliatus*

1. *S. linifolius* (Walt.) B.S.P. Frequent. Open pine woods and grass-weed borders. Summer.

2. *S. asteroides* (L.) B.S.P. Frequent. Open pine woods, cutover woodlands, and occasional in oak-hickory woods and grass-weed borders. Summer.

3. *S. bifoliatus* (Walt.) Porter. Occasional. Open pine woods and grass-weed borders in the sandy soils of the coastal plain section of Wake County. Autumn.

14. *Baccharis* L. Groundsel Tree

B. halimifolia L. Infrequent. Wet pine woods or in willow-alder thickets. Also naturalized as an escape from cultivation near old homesites in upland areas. Autumn.

15. *Pluchea* Cass. Marsh Fleabanes

a. Leaves, some of them, petioled, broadly elliptic to elliptic-lanceolate, serrate
1. *P. camphorata*

a. Leaves sessile, cordate-clasping, ovate to ovate-lanceolate, denticulate..2. *P. foetida*

1. *P. camphorata* (L.) D. C. (*P. petiolata* Cass. *sensu* authors). Occasional. Wet woods and seepage slopes. Late summer and autumn.

2. *P. foetida* (L.) D. C. Occasional. Seepage slopes and bogs. Late summer and autumn.

16. *Antennaria* Gaertn. Pussy Toes

a. Stolons long-filiform, tardily producing rosettes of leaves; heads solitary.*
1. *A. solitaria*

a. Stolons promptly assurgent with leafy tips or rosettes of leaves; heads in corymbs.

b. Pistillate involucres 5.7 mm. high; mature pappus 4–5.5 mm. long
2. *A. plantaginifolia*

b. Pistillate involucres 7–11 mm. high; mature pappus 6–8.5 mm. long.

c. Rosette leaves arachnoid-pubescent above, glabrate when old; stems and involucres not purplish.....3. *A. fallax*

c. Rosette leaves shiny-glabrous above even when young; stems and involucres purplish.....4. *A. Parlinii* var. *arnoglossa*

1. *A. solitaria* Rydb. Rare. North-facing, wooded stream bluffs. Spring.

2. *A. plantaginifolia* (L.) Richards. Frequent. Dry, sterile grass-weed borders and open pine woods. Spring.

3. *A. fallax* Greene. Frequent. Grass-weed borders and pine woods. Spring.

4. *A. Parlinii* Fern., var. *arnoglossa* (Greene) Fern. Frequent. Grass-weed borders and pine woods. Spring.

* Key to the Antennarias adapted from Fernald, Rhodora 47. 1945.

17. *Gnaphalium* L.

a. Heads in broad panicled cymes; pappus bristles distinct; achenes glabrous.
  b. Stem cobwebby or densely woolly-tomentose throughout.....1. *G. obtusifolium*
  b. Stem glandular-viscid, not woolly-tomentose.....2. *G. obtusifolium*, var. *Helleri*
a. Heads in axillary clusters; the inflorescence elongate; pappus bristles united at the base; achenes pubescent.
  c. Tomentum on stems and lower leaf surface dense and closely appressed white-cottony, appearing conspicuously silvery to the unaided eye, the tomentum on the upper leaf surfaces much less dense and the surfaces thus appearing somewhat green above; basal and lower cauline leaves thickish, oblanceolate to spatulate; involucres loosely enmeshed in tomentum at their bases, otherwise glabrous, the outer phyllaries short-ovate and scarious, the middle and inner green at the bases, purple-scarious near the middle, and yellow-scarious at the tips, linear-oblong.....3. *G. purpureum*
  c. Tomentum on stems and both leaf surfaces dense, but less closely appressed, both appearing faintly green through the silvery tomentum; basal and lower cauline leaves spatulate to linear-oblanceolate; involucres essentially glabrous but with some loose tomentum at their bases, the outer phyllaries narrowly ovate, the inner linear-oblong, all essentially yellow-scarious.....4. *G. calviceps*
  c. Tomentum on stems and lower leaf surfaces thin and loosely appressed, on the upper leaf surfaces very thin and loose, the plants thus appearing dull-green throughout; basal and lower cauline leaves thinnish, broadly spatulate to obovate; involucres copiously enmeshed in tomentum, the outer phyllaries ovate, tapering gradually to the summits, the middle and inner phyllaries with green centers and scarious margins below and yellow-sacrious tips, broadest at the bases and tapering gradually to the tips.....5. *G. peregrinum*

1. *G. obtusifolium* L. Everlasting. Frequent. Broom sedge old fields, occasional in the tall weed stages of the old fields; frequent in open pine woods and grass-weed borders. Summer and autumn.

2. *G. obtusifolium* L., var. *Helleri* (Britton) Fern. Occasional. Open pine woods and grass-weed borders. Autumn.

3. *G. purpureum* L. Cudweed. Frequent. Sterile, sparsely populated grass-weed borders, and in old fields following cultivation. Spring and summer.

4. *G. calviceps* Fern. Frequent. Occurring in the same situations as *G. purpureum* and the next. Summer.

5. *G. peregrinum* Fern. (*G. spathulatum* of authors) Frequent. Spring and summer.

18. *Polymnia* L.

P. Uvedalia L., var. *floridana* Blake. Frequent. Moist cut-over woodlands, and in moist tall weed thickets. Late summer and early autumn.

19. *Acanthospermum* Schrank

A. australe (Loefl.) Ktze. Spiny Bur. Infrequent as a lawn weed or in dry, sterile grass-weed borders. Late summer.

20. *Silphium* L. Rosin Weeds

a. Plants with stems leafy throughout.
b. Phyllaries pubescent and with ciliate margins; peduncles densely hispidulose ..... 1. *S. scaberrimum*
b. Phyllaries not pubescent, but ciliate; peduncles glabrous or sparingly hispidulose ..... 2. *S. astericus*
a. Plants with leaves mostly near the base of the stem; the scapose inflorescence tall, paniculed at the summit.
c. Leaves pedately lobed or divided ..... 3. *S. compositum*
c. Leaves coarsely dentate ..... 4. *S. terebinthinaceum*

1. *S. scaberrimum* Ell. Frequent. Open pine woods, grass-weed borders, and tall weed thickets. Late summer and autumn.

2. *S. astericus* L. Infrequent in similar situations to No. 1.

3. *S. compositum* Michx. Frequent. Open pine woods and grass-weed borders, occasionally in oak-hickory woods. Summer.

4. *S. terebinthinaceum* Jacq. Probably a waif. One collection made along the Seaboard Airline R. R. tracks at Apex, N. C. Summer.

21. *Chrysogonum* L.

C. virginianum L. Golden Star. Frequent. Pine woods, oak-hickory woods, and beech-maple woods; occasional in stream bank woods. Spring.

22. *Parthenium* L. Feverfew

a. Stem glabrous below, puberulent above; cauline leaves sessile, not auricled ..... 1. *P. integrifolium*
a. Stem villous; cauline leaves auriculate-clasping ..... 2. *P. auriculatum*

1. *P. integrifolium* L. Frequent. Open pine woods, grass-weed borders, broom sedge old fields. Spring, summer, and autumn.

2. *P. auriculatum* Britton. Rare. Grass-weed borders. The only collections are from Durham County. Spring and summer.

23. *Ambrosia* (Tourn.) L. Ragweeds

a. Leaves bi- or tripinnatifid ..... 1. *A. artemisiaefolia* var. *elatior*
a. Leaves not pinnatifid, but some of them deeply three-lobed, serrate ..... 2. *A. trifida*

1. *A. artemisiaefolia* L., var. *elatior* (L.) Descourt. Common ragweed. Frequently a dominant weed in the lowland old fields in the tall weed stage of succession; frequent also as a weed in gardens and around buildings. Late summer and early autumn.

2. *A. trifida* L. Great ragweed. Frequent. Tall weed thickets. Late summer and autumn.

24. *Xanthium* (Tourn.) L. Cocklebur

a. Burs minutely glandular-puberulent or glabrate ..... 1. *X. chinense*
a. Burs coarsely hispid, especially on the spines ..... 2. *X. pennsylvanicum*

1. *X. chinense* Miller. Frequent as a dominant in the lowland old fields· occasional along open stream banks. Late summer and autumn.

2. *X. pennsylvanicum* Wallr. Infrequent. Seepage slopes and wet pastures. Late summer and autumn.

25. *Heliopsis* Pers. Ox-eye

H. helianthoides (L.) Sweet. Frequent. Moist, open pine or oak-hickory woods, and in lowland cut-over woodlands. Summer.

26. *Eclipta* L.

E. alba (L.) Hassk. Occasional. Weed in lowland fields under cultivation; also in the crabgrass stage of the old fields. Summer.

27. *Tetragonotheca* (Dill.) L.

T. helianthoides L. Infrequent. Grass-weed borders and open pine woods. Late spring and early summer.

28. *Rudbeckia* L. Cone-flowers

a. Disk corollas yellow.....1. *R. laciniata*
a. Disk corollas deep purple or black.
  b. Plants very rough and bristly hairy throughout; rays approximately 2–3.5 cm. long; pappus none.....2. *R. hirta*
  b. Plants with spreading hirsute pubescence, but not very rough and bristly; rays approximately 1–1.5 cm. long; pappus a short crown.....3. *R. fulgida*

1. *R. laciniata* L. Goldenglow. Frequent. Tall weed thickets, and in wet woods and stream bank woods. Late summer and autumn.

2. *R. hirta* L. Black-eyed Susan. Infrequent. Grass-weed borders and open pine woods. Summer.

3. *R. fulgida* Ait. Frequent. Moist pine woods and grass-weed borders. Late summer and autumn.

29. *Brauneria* Neck

B. laevigata Boynt. and Beadle. (*Echinacea laevigata* (B. & B.) Small) Purple cone flower. Rare. Grass-weed borders. Early summer.

30. *Helianthus* L. Sunflowers

a. Disk corollas reddish-brown.
  b. Cauline leaves of a lanceolate or linear type, sessile or nearly so
    1. *H. angustifolius*
  b. Cauline leaves of an ovate type, the lower with petioles.
    c. Basal leaf blades ovate or oval, crenate to dentate, blunt, bases abruptly contracted into winged petioles; middle phyllaries broadly rounded to abruptly short-acuminate.....2. *H. atrorubens*
    c. Basal leaf blades ovate to broadly lanceolate, serrate to serrate-dentate, acute, bases gradually tapering into a winged-petiole; middle phyllaries acute
      3. *H. atrorubens*, var. *alsodes*

a. Disk corollas yellow.
d. Stems smooth below, pubescent in the inflorescence if at all.
e. Involucres not over 8 mm. broad; stems smooth throughout, not glaucous
4. *H. microcephalus*
e. Involucres 1 cm. broad or broader; stems glabrous below, usually pubescent in the inflorescence.
f. Leaf blades broadest at the base, subsessile, divaricate.....5. *H. divaricatus*
f. Leaf blades narrowed at base into winged petioles.
g. Leaves membranaceous, green above and below, sparingly setose above and below; phyllaries linear-lanceolate.....6. *H. decapetalus*
g. Leaves thickish, green and setose above, glaucous below but with setae on the principal veins; phyllaries broadly lanceolate.....7. *H. strumosus*
d. Stems pubescent throughout.
h. Leaves alternate throughout.....8. *H. giganteus*
h. Leaves opposite on the lower part of the stem at least.
i. Leaves and branches opposite below, becoming alternate in the inflorescence.
j. Leaves short hirsute beneath; internodes of the inflorescence zigzagging
9. *H. tuberosus*
j. Leaves tomentose beneath; internodes of the inflorescence not zigzagging
10. *H. tomentosus*
i. Leaves and branches all opposite.....11. *H. hirsutus*

1. *H. angustifolius* L. Occasional. Bogs, meadows, and low, wet, open pine woods. Autumn.

2. *H. atrorubens* L. Frequent. Open pine woods, grass-weed borders, and occasional in oak-hickory woods. Late summer and autumn.

3. *H. atrorubens* L., var. *alsodes* Fern. Occasional. Similar habitats. Late summer and autumn.

4. *H. microcephalus* T. & G. Frequent. Tall weed thickets, edges of woods, and grass-weed borders. Late summer and autumn.

5. *H. divaricatus* L. Frequent. Grass-weed borders, open pine woods and cut-over woods. Summer.

6. *H. decapetalus* L. Frequent. Cut-over woodlands and moist tall weed thickets. Summer and autumn.

7. *H. strumosus* L. Frequent. Cut-over woodlands, open pine woods, and tall weed thickets. Summer and autumn.

8. *H. giganteus* L. Occasional. Tall weed thickets, and wet, open woods. Summer and autumn.

9. *H. tuberosus* L. Frequent. Tall weed thickets and grass-weed borders. Summer and autumn.

10. *H. tomentosus* Michx. Occasional. Lowland, open pine woods and moist tall weed thickets. Summer and autumn.

11. *H. hirsutus* Raf. Occasional. Pine and oak-hickory woods. Summer.

31. *Actinomeris* Nutt.

A. alternifolia (L.) DC. (*Ridan alternifolia* (L.) Britton). Stick weed. Occasional. Tall weed thickets, wooded stream bluffs. Summer and autumn.

32. *Verbesina* L.

V. occidentalis (L.) Walt. (*Phaethusa occidentalis* (L.) Small) Crownbeard. Frequent. Tall weed thickets, cut-over woodlands, lowland pastures and stream banks. Summer and autumn.

33. *Coreopsis* L. Tickseeds

a. Disk flowers red.....1. *C. falcata*
a. Disk flowers yellow.
b. Leaves all divided into filiform segments.....2. *C. verticillata*
b. Leaves entire or divided, but segments never filiform.
c. Leaves, all sessile, each leaf divided into three entire, elliptic-lanceolate leaflets, the two opposite leaves, therefore, appearing like a whorl of six; plants erect
3. *C. major*, var. *stellata*
c. Leaves, the lower at least, petioled, entire or pedately divided; plants low and spreading; lower leaves ovate, ovate-lanceolate, or rarely obovate, often with basal lobes or divisions.....4. *C. auriculata*

1. *C. falcata* Boynt. Occasional. Bogs, and wet ditches. Late spring or early summer.

2. *C. verticillata* L. Frequent. Open pine woods, grass-weed borders, and cut-over woods. Summer.

3. *C. major* Walt., var. *stellata* (Nutt.) Robinson. Frequent. Sandy, open pine woods, and grass-weed borders; occasional in cut-over woodlands. Summer.

4. *C. auriculata* L. Frequent. Lowland pine woods, oak-hickory and beech-maple woods. Spring.

Several of the cultivated species of *Coreopsis* may be found locally abundant in grass-weed borders along roadsides and in the vicinity of dwellings. No attempt has been made to include them here.

34. *Bidens* L. Beggar Ticks

a. Leaves 1–3 pinnately parted or divided, the divisions not forming definite leaflets; achenes much exserted beyond the tips of the phyllaries; achenes very unequal in size
1. *B. bipinnata*
a. Leaves entire or pinnately compound; achenes about equaling the inner phyllaries; achenes about equal in size.
b. Leaves simple.....2. *B. connata* var. *petiolata*
b. Leaves pinnately compound.
c. Rays conspicuous, much exceeding the disk.....3. *B. aristosa*
c. Rays absent, or little if any exceeding the disk and inconspicuous.
d. Heads small, about 5 mm. high; awns of the achene 1–2 mm. long, upwardly barbed; rays none.....4. *B. discoidea*
d. Heads larger, 1 cm. or more high; awns of the achenes 3–5.5 mm. long, retrorsely barbed; rays present.
e. Outer foliaceous phyllaries 10–16, much exceeding the disk; rays yellow; achenes dark brown or blackish; setae on the achene margins retrorse
5. *B. vulgata*
e. Outer foliaceous phyllaries 6–8, little exceeding the disk; rays orange; achenes olive green; setae on the achene margins erect.....6. *B. frondosa*

1. *B. bipinnata* L. Spanish needles. Frequent as a weed in gardens and around buildings, in moist thickets, pastures, and on brook banks. Summer and autumn.

2. *B. connata* Muhl., var. *petiolata* (Nutt.) Farwell. Occasional. Brook banks, swamp clearings, wet pastures and thickets. Summer and autumn.

3. *B. aristosa* (Michx.) Britton. Frequent. Grass-weed borders. Autumn.

4. *B. discoidea* (T. & G.) Britton. Frequent. Wet woods, moist grass-weed borders and pastures. Summer and autumn.

5. *B. vulgata* Greene. Frequent. Habitat as in No. 4. Summer and autumn.

6. *B. frondosa* L. Frequent. Habitat as in No. 4. Summer and autumn.

35. *Marshallia* Schreb.

M. obovata (Walt.) Beadle and Boynt., var. *platyphylla* (Curtis) Beadle & Boynt. Frequent. Open pine woods and grass-weed borders. Spring and early summer.

36. *Galinsoga* R. & P.

G. ciliata (Raf.) Blake. Richweed. Occasional. Garden weed in very fertile soil. Summer and autumn.

37. *Madia*

Madia sativa Molina. Tarweed. Rare, perhaps a waif. Known in the area from Durham County only. Summer.

38. *Helenium* L. Sneezeweed

a. Leaves linear-filiform, not decurrent on the stem.....1. *H. tenuifolium*
a. Leaves broader, lanceolate to elliptic or oblanceolate, decurrent on the stem.
b. Stem simple or little branched with one or only a few heads on long peduncles; principal leaves oblanceolate with wavy margins.....2. *H. Curtisii*
b. Stem much branched with many heads on relatively short peduncles; leaves elliptic, lanceolate, or oblanceolate, serrate to sub-entire
3. *H. autumnale*, var. *parviflorum*

1. *H. tenuifolium* Nutt. Frequent. Grass-weed borders, pastures, and around farm buildings. Late summer and autumn.

2. *H. Curtisii* A. Gray. Occasional. Bogs. Early summer.

3. *H. autumnale* L. var. *parviflorum* (Nutt.) Fern. Occasional. Moist tall weed thickets, wet woodlands, and seepage slopes. Late summer and autumn.

39. *Tagetes* L. Marigold

T. minuta L. Frequent. As a weed in gardens and occasionally in fields. Autumn.

40. *Achillea* (Vaill.) L.

A. millefolium L. Yarrow, Milfoil. Frequent. Grass-weed borders, old fields, open stream banks, and in pastures. Late spring and summer.

41. *Anthemis* (Michx.) L.

a. Plants pubescent; leaves 1–2 pinnately parted into linear or lanceolate, acute lobes; pappus a minute border.....1. *A. arvensis*
a. Plants essentially glabrous; leaves 1–3 pinnately dissected into narrowly filiform, acute lobes; pappus none.....2. *A. Cotula*

1. *A. arvensis* L. Corn Camomile. Frequent. Grass-weed borders, and in fields the year following tilling. Spring and early summer.

2. *A. Cotula* L. (*Maruta Cotula* (L.) DC.) Mayweed. Frequent. Grass-weed borders, pastures, and in fields the year following tilling. Spring and early summer.

42. *Chrysanthemum* (Tourn.) L. Ox-eye daisy

C. leucanthemum L., var. *pinnatifidum* Lecoq and Lamotte. Frequent in fields the year following cultivation; frequent also in other stages of the old field succession and in grass-weed borders. Late spring and early summer.

43. *Arnica* L.

A. acaulis (Walt.) B.S.P. Frequent. Open pine woods, wet pastures, and occasional in grass-weed borders. Early summer.

44. *Erechtites* Raf. Fireweed

E. hieracifolia (L.) Raf. Frequent. Cut-over woodlands and weed borders, particularly where fire has occurred. Late summer and autumn.

45. *Cacalia* L. Indian Plantain

C. atriplicifolia L. (*Mesadenia atriplicifolia* (L.) Raf.) Frequent. Moist, tall weed thickets, particularly in cut-over woodlands; occasional also in pine woods, grass-weed borders, and oak-hickory woods. Late summer.

46. *Senecio* (Tourn.) L.

a. Ray flowers absent; leaves all pinnatifid; plant annual.....1. *S. vulgaris*
a. Ray flowers present; some of the basal and lower cauline leaves not pinnatifid, ovate-cordate, or lanceolate to oblanceolate, crenate-serrate, gradually becoming pinnatifid upward.
  b. Basal leaf blades ovate-cordate.....2. *S. aureus*
  b. Basal leaf blades oblong to broadly elliptic-lanceolate, or lanceolate to oblanceolate, narrowed at the base, not cordate.
    c. Basal leaf blades oblong to broadly elliptic-lanceolate or lanceolate; plants floccose-tomentose throughout when young, leaves and stems becoming glabrate above, the lower leaf surfaces remaining somewhat tomentose even in age 3. *S. tomentosus*
    c. Basal leaf blades lanceolate to oblanceolate; stems floccose-tomentose only near the bases, the leaves glabrous above.
      d. Heads 1 cm. high, 6–7 mm. broad at the bases of the involucres; rays ca. 1 cm. long; achenes essentially glabrous.....4. *S. pauperculus*, var. *praelongus*
      d. Heads not over 8 mm. high, less than 5 mm. broad at the bases of the involucres; rays ca. 6 mm. long; achenes copiously pubescent.....5. *S. Smallii*

1. *S. vulgaris* L. Groundsel. Occasional as a weed in fields and around buildings. Winter and spring.

2. *S. aureus* L. Infrequent. Wet, springy woods and meadows. Spring.

3. *S. tomentosus* Michx. Rare in the area, the only known station being in Wake County, sphagnous meadow. Spring.

4. *S. pauperculus* Michx., var. *praelongus* (Greenm.) House. Rare. The only station known for this plant is in Durham County, edge of woods along the old Oxford Road, where Dr. Blomquist discovered it in April, 1949.

5. *S. Smallii* Britton. Frequent. Broom sedge old fields, grass-weed borders, and open pine woods. Spring.

47. *Arctium* L.

A. minus Bernh. Burdock. Rare. Around gardens and buildings. Late summer.

48. *Cirsium* (Tourn.) Hill. Thistles

a. Heads subtended by foliaceous, spinescent bracts.....1. *C. spinosissimum*
a. Heads not subtended by foliaceous, spinescent bracts.
  b. Phyllaries not spine-tipped.....2. *C. muticum*
  b. Phyllaries, the outer at least, spine-tipped.
    c. Plants low and decumbent; spiny tips of the phyllaries appressed-erect 3. *C. repandum*
    c. Plants erect; spiny tips of the phyllaries spreading.
      d. Heads on leafy branches, short pedunculate; leaf margins flat.
        e. Leaves all 1–2 pinnatifid, broadly lanceolate or oblong, decurrent; inner phyllaries as well as the outer, spine-tipped.....4. *C. vulgare*
        e. Leaves merely toothed or sparingly sinuate-lobed, a few sometimes pinnatifid, elliptic, not decurrent; inner phyllaries with soft, flat tips 5. *C. altissimum*
      d. Heads terminating long, bracted peduncles; leaf margins revolute 6. *C. revolutum*

1. *C. spinosissimum* (L.) Scop. (*C. spinosissimum* (Walt.) Scop. of authors) Yellow thistle. Frequent. Grass-weed borders, open pine woods, and occasionally in the broom sedge old fields. Spring. There is a form of this species with purple corollas which is locally abundant in the piedmont of North Carolina, but I have not seen it in the area.

2. *C. muticum* Michx. Swamp thistle. Occasional. Lowland pine woods, wet woods, and moist tall weed thickets. Summer and autumn.

3. *C. repandum* Michx. Frequent in open pine woods, grass-weed borders, and old fields in the sandy soils of the coastal plain section of Wake County; rare elsewhere in the area. Summer and autumn.

4. *C. vulgare* (Savi) Airy-Shaw. (*C. lanceolatum* (L.) Hill. of authors). Bull thistle. Frequent. Open pine woods, grass-weed borders, and pastures. Summer.

5. *C. altissimum* (L.) Spreng. Tall thistle. Infrequent. Open woods. Summer.

6. *C. revolutum* Small (*C. virginianum* (L.) Michx., forma *revolutum* (Small) Fern.). Infrequent. Moist, open pine woods and bogs. Summer.

49. *Centaurea* L. Corn Flower

C. Cyanus L. Frequent. Grass-weed borders, and as a weed in clover and grain fields. Spring.

50. *Cnicus* L. Blessed Thistle

C. benedictus L. Occasional in fields the year following cultivation, and in lawns and grass-weed borders. Spring.

51. *Cichorium* (Tourn.) L. Chicory

C. Intybus L. Occasional in the tall weed old fields and grass-weed borders. Summer.

52. *Krigia* Schreb. Dwarf Dandelions

a. Pappus of 5-short, roundish scales, and 5–10 bristles.....1. *K. virginica*
a. Pappus of 10–15 linear-oblong scales, and 15–20 bristles.....2. *K. dandelion*

1. *K. virginica* (L.) Willd. Frequent in fields the year following cultivation; also in lawns, pastures, and sterile grass-weed borders. Spring.

2. *K. dandelion* (L.) Nutt. Frequent. Meadows, pastures, grass-weed borders, and fields following cultivation. Spring.

53. *Hypochaeris* L. Cat's Ear

H. radicata L. Occasional. Grass-weed borders, and in old fields the year after cultivation. Spring and early summer.

54. *Taraxacum* (Haller) Ludwig. Dandelions

a. Achenes olive-green; leaves pinnatifid, the lobes usually not runcinate; involucre not glaucous; phyllaries with no callosity on the back.....1. *T. palustre*, var. *vulgare*
a. Achenes reddish; leaves runcinate-pinnatifid; involucre glaucous; phyllaries with a callosity on the back near the summit.....2. *T. laevigatum*

1. *T. palustre* (Lyons) Lam. & DC., var. *vulgare* (Lam.) Fern. (*T. officinale* Weber; *Leontodon Taraxacum* L.). Frequent as a weed in lawns, pastures, and roadsides. Spring.

2. *T. laevigatum* (Willd.) DC. (*T. erythrospermum* Andrz.; *Leontodon erythrospermum* (Andrz.) Britt.) Frequent in similar habitats to No. 1. Spring.

55. *Sonchus* (Tourn.) L. Sow Thistles

a. Leaf auricles acute; achenes wrinkled and striate.....1. *S. oleraceus*
a. Leaf auricles rounded; achenes not wrinkled, 3-ribbed.....2. *S. asper*

1. *S. oleraceus* L. Infrequent as a weed in gardens, fields, and grass-weed borders. Spring.

2. *S. asper* (L.) Hill. Frequent in habitats as for No. 1. Spring.

56. *Lactuca* (Tourn.) L. Wild Lettuces

a. Achenes with distinct, long-filiform beaks.
b. Heads 6–12-flowered; leaf margins spiny-toothed.....1. *L. scariola*
b. Heads 12–20-flowered; leaf margins not spiny-toothed.
c. Leaves oblanceolate or obovate, sometimes with small shallow lobes but definitely not pinnatifid, margins entire to denticulate.
d. Stems glabrous except sometimes at the base; leaves glabrous 2. *L. canadensis*, var. *obovata*
d. Stems villous into the inflorescence; leaves villous on the midribs 3. *L. canadensis*, var. *obovata*, forma *Steelei*
c. Leaves in outline linear, lanceolate, ovate-lanceolate, or oblong, entire to pinnatifid.
e. Leaves sagittate-clasping, ovate-lanceolate to oblong, rays yellowish or cream-colored.
f. Lower leaves oblong, pinnatifid, with ovate or obovate runcinate lobes; upper leaves lanceolate, not lobed....4. *L. canadensis*, var. *latifolia*
f. Lower and upper leaves all ovate-lanceolate, entire to denticulate, the lowermost sometimes with very shallow dentate lobes 5. *L. canadensis*, var. *integrifolia*
e. Leaves not sagittate-clasping, the lower pinnatifid, the blades with narrow central portion from which arise linear-runcinate lobes, the upper elongate linear; rays blue, sometimes fading to whitish.....6. *L. graminifolia*
a. Achenes not filiform-beaked, truncate or with a short, thick beak.
g. Achenes truncate, not at all beaked; leaves ovate to oblong-lanceolate, rarely runcinate-lobed.....7. *L. villosa*
g. Achenes with a short, thick beak; leaves all lyrate, or the blades lyrate in outline but with runcinate lobes at the bases.....8. *L. floridana*

1. *L. scariola* L. Prickly Lettuce. Frequent in grass-weed borders, around farm buildings in weedy places, and occasional in tall weed old fields. Some plants have pinnatifid leaves; others do not. Summer.

2. *L. canadensis* L., var. *obovata* Wieg. Occasional in old fields, grass-weed borders, tall weed thickets, and cut-over woodlands. Summer.

3. *L. canadensis*, var. *obovata*, forma *Steelei* (Britton) Fernald. Occasional along with the variety.

4. *L. canadensis*, var. *latifolia* O. Kuntze. Frequent in tall weed thickets, grass-weed borders, and cut-over woodlands; occasional in the tall weed old fields. Summer.

5. *L. canadensis*, var. *integrifolia* (Bigelow) Gray. (*L. sagittifolia* Ell.). Occasional in grass-weed borders, old fields, and cut-over woodlands. Summer.

6. *L. graminifolia* Michx. Infrequent in dry oak-hickory woods, and grass-weed borders. Spring and summer.

7. *L. villosa* Jacq. Infrequent in stream-bank woods, other moist woods. Late summer and autumn.

8. *L. floridana* (L.) Gaertn. Occasional in tall weed thickets, lowland cut-over woods, and stream bank woods. Late summer and autumn.

57. *Pyrrhopappus* DC. False Dandelion

P. carolinianus (Walt.) DC. Frequent in meadows, grass-weed borders, weedy places around buildings, and occasional in the old fields. Spring and summer.

58. *Crepis* L. Hawksbeard

Crepis pulchra L. Infrequent. Grass-weed borders. Late spring and early summer.

59. *Prenanthes* (Vaill.) L.

a. Involucre of 5 elongate inner phyllaries which equal or slightly exceed the pappus; heads very narrow, not over 3 mm. wide.....1. *P. altissima*
a. Involucre of 6–8 elongate inner phyllaries which do not equal the pappus, the pappus thus exserted; heads broader, 5 mm. broad or more.....2. *P. serpentaria*

1. *P. altissima* L. Frequent. Oak-hickory woods; occasional in moist, cut-over woodlands and in pine woods. Autumn.

2. *P. serpentaria* Pursh. Frequent. Open pine woods, cut-over woods; occasional in tall weed thickets. Late summer and autumn.

60. *Hieracium* (Tourn.) L. Hawkweeds

a. Principal leaves basal.
  b. Leaves characteristically purplish or with purple veins; scapes and phyllaries usually purplish, glabrous or very sparingly glandular-pubescent.....1. *H. venosum*
  b. Leaves and scapes not purplish; scapes and phyllaries copiously glandular-pubescent.
    c. Mature achenes narrowed at the summit; pubescence of the scapes and phyllaries cinereous; heads numerous on relatively tall, open, cymose panicles or elongate racemose panicles; plants not stoloniferous.....2. *H. Gronovii*
    c. Mature achenes not narrowed from the middle to the summit; pubescence of the scapes and phyllaries black; heads solitary or few on low, naked scapes; plants with elongate, leafy stolons.....3. *H. pilosella*
a. Principal leaves cauline.
  d. Mature achenes narrowed at the summit; leaves obovate, obtuse or broadly rounded at the apices, the lowermost gradually narrowed to winged petioles, pubescent at least below, often shaggy pubescent on the stem and on the leaf margins; peduncles glandular pubescent.....2. *H. Gronovii*
  d. Mature achenes not narrowed from the middle to the summit; leaves lanceolate to elliptic or oblanceolate, acute or acuminate at the apices, narrowed to the sessile bases, glabrous; peduncles glabrous.....4. *H. paniculatum*

1. *H. venosum* L. Rattlesnake weed. Frequent. Various types of woods, and grass-weed borders at margins of woods. Spring.

2. *H. Gronovii* L. Frequent. Dry, open woods, cut-over woods, and grass-weed borders. Many of our plants are leafy-stemmed, and have elongate, racemose panicles of heads. These are probably *H. Gronovii*, var. *foliosum* Michx., but the species is so variable and one extreme grades into the other to such an extent that I hesitate to apply names to the extremes. Summer.

3. *H. pilosella* L. Rare. Open woods and banks. Spring and early summer.

4. *H. paniculatum* L. Rare. Oak-hickory woods. Summer and autumn.

BIBLIOGRAPHY

BLAKE, S. F. 1941. Note on the name *Eupatorium rugosum*. Rhodora **43**: 557–558.

BLOMQUIST, H. L., AND OOSTING, H. J. 1948. A guide to the spring and early summer flora of the Piedmont, North Carolina. Published by the authors, Durham, N. C.

CRONQUIST, ARTHUR. 1945. Notes on the Compositae of the Northeastern United States. I. Inuleae. Rhodora **47**: 182–184.

———. 1945. Notes on the Compositae of the Northeastern United States. II. Heliantheae and Heleniеae. Rhodora **47**: 396–403.

———. 1946. Notes on the Compositae of the Northeastern United States. III. Inuleae and Senecioneae. Rhodora **48**: 116–125.

FERNALD, M. L., AND GRISCOM, LUDLOW. 1935. Three days of botanizing in Southeastern Virginia. Rhodora **37**: 179–186.

FERNALD, M. L. 1935. Midsummer vascular plants of Southeastern Virginia. Rhodora **37**: 446–451.

———. 1936. Contrib. Gray Herb. CXIII. VI. Studies in Solidago. Rhodora **38**: 201–229; VII. Memoranda on Antennaria. Rhodora **38**: 229–231; VIII. Varieties of *Gnaphalium obtusifolium*. Rhodora **38**: 231–233.

———. 1937. Local plants of the inner Coastal Plain of Southeastern Virginia. Rhodora **39**: 321–366; 451–459.

———. 1938. Contrib. Gray Herb. CXXII. VII. New species, varieties and transfers. Rhodora **40**: 344–357.

———. 1938. Plants from the outer Coastal Plain of Virginia. Rhodora **40**: 445–450.

———. 1938. Noteworthy plants of Southeastern Virginia. Rhodora **40**: 467–482.

———. 1939. Last survivors in the flora of Tidewater Virginia. Rhodora **41**: 571–574.

———. 1940. A century of additions to the flora of Virginia. Rhodora **42**: 481–498.

———. 1941. Another century of additions to the flora of Virginia. Rhodora **43**: 652–657.

———. 1942. The seventh century of additions to the flora of Virginia. Rhodora **44**: 458–478.

———. 1943. Virginian botanizing under restrictions. Rhodora **45**: 477–480; 485–511.

———. 1945. Botanical specialties of the Seward Forest and adiacent areas of Southeastern Virginia. Rhodora **47**: 191–197.

———. 1945. Contrib. Gray Herb. CLVII. I. Key to Antennaria of the "Manual Range." Rhodora **47**: 221–235; 239–244.

———. 1946. Technical studies on North American plants. Rhodora **48**: 65–80.

GAISER, L. O. 1946. The genus Liatris. Rhodora **48**.

HARRIS, STUART K. 1943. Notes on Solidago, section Euthamia. Rhodora **45**: 413.

HUNT, K. W. 1947. The Charleston woody flora. Amer. Midl. Nat. **37**: 67–756.

MACKENZIE, KENNETH K. 1920. Scientific names applicable to our purple-flowered Eupatoriums. Rhodora **22**: 157–165.

PEATTIE, D. C. 1946. The use and uselessness of local floras. Castanea **11**: 63–65.

PERRY, LILY M. 1937. Contr. Gray Herb. CXVIII. I. Notes on Silphium. Rhodora **39**: 281–297.

SMALL, J. K. 1933. Manual of the Southeastern Flora. Published by the author. New York.

WIEGAND, K. M. 1920. Variations in *Lactuca canadensis*. Rhodora **22**: 9–11.

———. 1920. *Eupatorium purpureum* and its allies. Rhodora **22**: 55–70.

———. 1928. *Aster lateriflorus* and some of its relatives. Rhodora **30**: 161–179.

———. 1933. *Aster paniculatus* and some of its relatives. Rhodora **35**: 16–38.

———, AND WEATHERBY, C. A. 1937. Contr. Gray Herb. CXVIII. II. The nomenclature of the verticillate Eupatoria. Rhodora **39**: 297–306.

ORIGINAL TREELESS AREAS IN WEST VIRGINIA

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The statement is generally made that the original vegetation of the middle Appalachian region consisted of some type of forest cover. It is well known, however, that thousands of acres of this area were treeless at the time of the first exploration by European colonists.

George Washington, in his Journal (Toner, 1892), refers to Old Fields and Wild Meadows, and the editor, Toner, gives the following explanation: "There were many small, timberless tracts of land on the mountains and in the great valleys of Virginia and Pennsylvania, in regions which were generally, prior to the occupation and the clearing of the country by the white man, densely covered with trees. Large tracts of such timberless land existed in the region now embraced within the counties of Berkeley, Jefferson and Frederick . . . In some respects these openings resembled the treeless prairies of the west. No satisfactory explanation of this frequently observed condition has ever been given. Many of these meadows were the favorite pasturing grounds of the large game and were . . . of special interest to hunters. Clearfield County, Pa., it is believed, got its name . . . [from] natural clear fields and meadows."

The investigation of these areas and the presentation of a satisfactory explanation of their original treeless condition is necessarily a difficult task at this late time, in view of the universally disturbed conditions, whereby even the precise location of many of the areas is now in doubt. Several possible explanations are here set forth and evidence from observed and recorded facts is advanced to provide what seems to be a satisfactory account.

1. *These areas may correspond to alpine meadows or tundra known to exist above timber line in many parts of the world.*

It is well known, however, that the Southern Appalachians do not afford elevations sufficient for the development of this type of vegetation. Timber line in the Rocky Mountains at the latitude of West Virginia is at approximately 10,000 feet above sea level. Spruce Knob, the highest point in West Virginia, is only 4860 feet above sea level. Furthermore, the original treeless areas, while found almost entirely within the mountain counties, were by no means confined to the higher elevations; as a matter of fact, most of them occur in mountain valleys.

2. *The areas may be of the same origin as the grass balds of the Southern Appalachians.*

Wells (1937) describes 23 *grass balds* of the southern Blue Ridge and the Great Smoky Mountains. Most of these, he states, are on gentle south slopes of rounded ridge tops or gaps near high bold springs. The explanation of these balds has been an enigma to naturalists for centuries. Wells proposed the theory that their

apparent artificial nature points towards their development as fields about Indian camp sites, where mountain grasses, particularly *Danthonia compressa*, obtained such a firm establishment as to be able to compete successfully against woody plants. Wells cites numerous facts in substantiation of this theory, particularly the location of the balds on gentle warm southern slopes near springs. Such descriptions are not applicable to original treeless areas in West Virginia and it may be assumed that Wells' theory, whether satisfactory or not for the balds, has no bearing on the present situation.

3. *The areas may represent heath scrub such as is developed on extremely acid soil in many parts of the world.*

The *heath balds* of North Carolina and Tennessee, in the same region as the grass balds, have also provoked much discussion on the part of botanists (Cain, 1930). Farther north, in the Alleghenies of West Virginia, there are areas which have some features in common with these balds. These Allegheny areas are locally called *huckleberry plains*. Numerous flat-topped mountain ranges above 4000 feet in elevation are covered with a type of vegetation dominated by ericads, particularly species of *Gaylussacia* and *Vaccinium* which are locally of some economic value to mountain folk. Thousands of acres of uninhabited, rolling, treeless barrens are swept by winds often of terrific force, explaining the name Roaring Plains, applied to the largest such area. Scarcely any evidence of a possible earlier forest cover is to be found and it is easy to form the conjecture that the vegetation for centuries has been similar to that existing at present. It has been shown, however, that there is historical proof that the region was once covered with a fine forest which has been destroyed by repeated fires (Core, 1939).

4. *The areas may have represented relict prairies such as are known from Ohio.*

Transeau's classic studies (1935) of the "Prairie Peninsula" are well known, and his location of the eastern boundaries through soil studies, floristic studies, historical records and the like, have reached a high degree of accuracy. While some of the prairie species are represented in the flora of the Alleghenies, the treeless areas of West Virginia have no more than superficial resemblance to prairie lands. The soil types characteristic of climax grasslands, for example, do not occur in the grassy areas of the Alleghenies, nor do the floristic lists coincide. Regardless of the theories that may be accepted to account for the eastward extension of prairies, there seems no reason to doubt the general accuracy of Transeau's map, which represents the eastern outliers at about central Ohio.

5. *The areas may have been fields cleared and cultivated by the aborigines, on which successional processes of a secondary nature were under way.*

There is abundant evidence that at least a few of the areas may be so explained. Early white explorers told of the primitive agriculture practised by the Indians and a few cleared fields existed in the neighborhood of their villages. Warner's map (1738) mentions "Shawno, Indian Fields". Mayo (1737) refers to "Old Fields", and "Shawno Indian Fields". Frye and Jefferson (1751) mention "Shawno Fields".

Kercheval (1833) identifies "Indian Old Fields" as follows: "On the Wappatomaka [The South Branch of the Potomac River], a few miles below the forks, tradition relates that there was a very considerable Indian settlement on the farm of Isaac Vanmeter, Esq. On this water course in the County of Hardy, when the county was first discovered, there was [sic] considerable openings of the land, or natural prairies, which are called the 'Indian old fields' to this day. Numerous Indian graves are to be seen in the neighborhood". A post office, Old Fields, exists at this point.

Butcher (1912) has the following definition: " 'Old Fields' is a common expression for land that has been cultivated by the Indians and left fallow, which is generally overrun with what they call 'broom grass' ".

These areas were doubtless very numerous, although small in size. In addition to the Old Fields post office, mentioned above, there is an Old Field Branch in Greenbrier County, an Old Field Fork in Lewis County and another in Pocahontas County, an Old Field Mountain in Greenbrier County and an Old Field Ridge in Pocahontas County. There seems no reason to doubt the explanation of their origin, as related by the early settlers. Nevertheless, they were very temporary and in a few years would doubtless have become forested again, unless maintained as cleared fields by the white successors to the original cultivators. They by no means account for the many areas where the treeless condition was apparently natural and of indefinite duration. It becomes necessary to look further for an explanation of these.

6. *The areas may be regarded as natural grasslands representing a vegetational type which may be called a glade.*

The term *glade*, according to the Century Dictionary and Cyclopedia was not found in middle English or Anglo-Saxon, but is derived from the Middle English word *glad*, smooth, bright, joyful, derived from the Anglo-Saxon glaed, shining, bright, cheerful (the origin of modern *glad*). In its original sense it was "a smooth bare place or perhaps a bright, light, clear place, as in a wood" (cf. Spenser's Faerie Queene, VI. iv. 13). The *Dictionary of American English* defines glade as "a natural or artificial opening or clearing in a forest." A tract of low swampy land, sometimes inundated and often overgrown with grass; an everglade". It may now be profitable to examine some of the early accounts of the Appalachian glades.

The *Blackwater Chronicle* (Kennedy, 1853), an account of a visit to the Blackwater River section, in Tucker County, has numerous references to glades in the then trackless forests: p. 89: "We at length descended into a beautiful little glade—more properly a dale in the mountains—some two hundred yards wide and two or three miles long"; p. 90: "rode on down the middle of the wild meadow, through green grass, knee-high, and waving gently in the summer wind, until we reached a small stream, whose banks were overgrown with osiers and other delicate shrubs"; p. 102: "winding through the long grass by a track made by the deer" . . . p. 118: "We came to the head of a glade, through which a stream of some size ran and threw ourselves down upon the soft, beautiful grass, knee-high everywhere around".

A Visit to the Virginian Canaan (Strother), written in 1857, has several references to the same region: p. 25: "After a march of six miles they entered a green glade of great beauty, watered by an amber rivulet, which they leaped with their packs and guns. . . . About five o'clock in the afternoon they emerged from the dreary forest into another waving glade, and at the farther border Thornhill gave the welcome order to halt for the night. . . . The horses, relieved of their burdens, were tethered in the glade, up to their bellies in grass".

In the autobiography of the famous hunter Meshach Browning (c. 1859), *glades* are mentioned in about 25 passages, of which the following are representative: p. 102: "proposed removing to the Glades, where we would be sure of plenty of grass for our stock"; p. 104: "proposed to walk a little through the beautiful glade, which was covered with grass knee high, and intermixed with wild flowers of all the kinds and colors that nature had ever produced; p. 361 et seq.: "The glades are, or then were, clear, level meadows, covered with high grass, which was altogether different from what is there produced now, being of a much better character, growing nearly as high as rye, with a blue tassel at the top. The blades were set very thick on the stalk, to the height of three or four feet [doubtless *Calamagrostis canadensis*]. I have often seen that grass tied in a knot over a horse's withers while his rider was sitting on him; and when it was cut in good season, it wintered cattle equally as well as timothy. There were then hundreds, if not thousands, of acres of this grass growing where there is now nothing but bushes, and a rough and very inferior kind of grass. . . . It was a grand sight to watch the tall grass, rolling in beautiful waves with every breeze which passed over its smooth surface, as well as the herds of deer. . . . The glades . . . are large, level bodies of lands, a part of which are open, natural, wild meadows, with a wet, marshy soil".

From these accounts it is readily apparent that the original glades were wet areas and it may be assumed that they represented poorly drained mountain valleys where the vegetation could be classified as a grass-sedge meadow, or *fen*, being a successional stage in the development of the climax deciduous forest characteristic of the region.

Certain areas are still more poorly drained and are characterized, not by a covering of tall grass, but by a mat of sphagnum, in which both the large and small cranberry may be found. These areas may be designated ecologically as *cranberry glades*, since their structure does not resemble exactly the bogs or muskegs (see Scott, 1949) of the North, to which they have been compared. The most famous of these areas is Cranberry Glades (Darlington, 1943), a 600-acre tract in Pocahontas County, but innumerable smaller cranberry glades occur in many places throughout the mountain counties. These areas are covered with peat, varying in thickness from a few inches to 10 feet or more. Acidity is usually very high. Most of the areas are partially covered with sphagnum, with such low seed plants as *Drosera*, *Menyanthes*, and numerous sedges, in addition to the cranberries.

It may be concluded, therefore, that the original treeless areas in the middle Appalachian region represented a relatively small number of "old fields" per-

sisting temporarily from Indian agriculture, but to a much greater extent intermediate stages of succession in the development of the climax association.

In the preparation of this paper, the writer has been greatly aided by use of the book, *West Virginia Place Names, their Origin and Meaning, Including the Nomenclature of the Streams and Mountains*, by Hamill Kenny, published in 1945 by The Place Names Press, Piedmont, West Virginia.

LITERATURE CITED

BROWNING, MESHACH c. 1859. Forty-four years of the life of a hunter; being reminiscences of Meshach Browning, a Maryland hunter.

BUTCHER, BERNARD L. 1912. Genealogical and personal history of the Upper Monongahela Valley, p. 203, quoting from the Reverend Clayton's Note in letter accompanying Batts and "Fallows" (sic) Journal.

CAIN, S. A. 1930. An ecological study of the heath balds of the Great Smoky Mountains. Butler Univ. Bot. Stud. **1**: 177–208.

CORE, E. L. 1939. The flora of Roaring Plains, West Virginia. Proc. W. Va. Acad. Sci. **12**: 33–35.

DARLINGTON, H. C. 1934. Vegetation and substrate of Cranberry Glades, West Virginia. Bot. Gaz. **104**: 371–393.

FRY, JOSHUA, AND PETER JEFFERSON 1751. A Map of the most inhabited part of Virginia containing the whole Province of Maryland with part of Pennsylvania, New Jersey and North Carolina. In the Library of Congress.

KENNEDY, PHILIP PENDLETON. 1853. The Blackwater Chronicle, a narrative of an expedition into the land of Canaan, in Randolph County, Virginia.

KERCHEVAL, SAMUEL. 1833. A history of the Valley of Virginia, p. 37.

MAYO, WILLIAM. 1737. A Map of the Northern Neck in Virginia. . . . Situate betwixt the Rivers Patomack and Rappahannock . . .; Drawn in the year 1737 by Wm. Mayo. In Library of Congress.

SCOTT, BURGESS H. 1949. The case of the misplaced muskeg. Ford Times, February, 1949, pp. 40–43.

STROTHER, DAVID HUNTER. 1857. Virginia Illustrated; containing a visit to the Virginian Canaan, and the adventures of Porte Crayon (pseud.) and his cousin.

TONER, J. M. [ed.] 1892. Journal of my [George Washington's] Journey over the mountains . . . while surveying for Lord Thomas Fairfax . . . in the Northern Neck of Virginia, beyond the Blue Ridge in 1747–8.

TRANSEAU, E. N. 1935. The prairie peninsula. Ecology **16**: 423–437.

WARNER, — — 1738. (Map) The courses of the Rivers Rappahannock and Potowmack, in Virginia, as surveyed according to order in the years 1736 and 1737. In Library of Congress.

WELLS, B. W. 1937. Southern Appalachian grass balds. Jour. Elisha Mitch. Sci. Soc. **53**: 1–26.

METHODS FOR STUDYING THE INFLUENCE OF SOCIO-ECONOMIC FACTORS ON THE GROWTH OF SCHOOL CHILDREN—BODY MEASUREMENTS

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The material presented in this paper represents the first step in a continuing investigation to test the hypothesis that the body measurements of children of school age can be used to study the level of nutrition of population groups. It is reasonable to believe that this might be so since the classical method in experimental nutrition has been the study of the growth in weight of young rats fed on diets being investigated. The use of measurements of height, weight, and other body dimensions as indices of the nutritional status of school children is, of course, not new. Our contribution is in the application of the statistical method of covariance to the problem of testing the significance of differences in the mean measurements of small groups of children drawn from varying socio-economic backgrounds. As will be seen below, this method permits heights and weights to be adjusted for age, and weights to be adjusted for both height and age, thus facilitating a comparison and analysis of the mean measurements of groups of children.

Previous reports in the literature demonstrating that the more privileged classes have taller, heavier children have been reviewed by Meredith (1941), and will not be detailed here. For the most part, reliance in published studies has been placed upon large samples of children of like age, and large differences in group means, rather than upon smaller samples of children of unequal age in which the variation introduced by age has been removed by statistical methods. The latter procedure is, however, most useful since it then becomes unnecessary to assemble such large groups of families homogeneous in their socio-economic backgrounds or diet patterns in order to obtain significant comparisons. It should be noted that in the area in which we are doing field studies, 1,000 families might be expected to furnish only 45 nine-year old boys. With the method we use, heights and weights can be adjusted for age, and it becomes possible to compare the mean measurements of groups of children whose ages vary over a three to five year span, thus reducing the number of families which must be sampled.

The diet patterns of human population groups are conditioned by a number of

socio-environmental factors, including folkways, education, home food production, income level, food costs, distribution and marketing of food, and facilities in the home for storing and preparing food. We believe that it is very likely indeed that the observed differences in mean heights and weights of groups of children from varying socio-economic backgrounds are due in part to inequal

TABLE 1

Observed and adjusted group mean measurements

	NUMBER OF CHILDREN	OBSERVED GROUP MEANS			MEAN HEIGHTS ADJUSTED FOR AGE*	MEAN WEIGHTS ADJUSTED FOR AGE*	MEAN WEIGHTS ADJUSTED FOR AGE and HEIGHT*
		Age	Height	Weight			
		mo.	*cm.*	*lbs.*	*cm.*	*lbs.*	*lbs.*
BOYS 108–167 months of age							
Private school urban	25	133.7	147.5	94.6	150.3 ± 1.28	99.4 ± 3.13	91.5 ± 2.51
Rural owner	48	142.2	145.2	80.5	144.8 ± 0.90	79.8 ± 2.19	80.7 ± 1.67
Rural tenant	35	146.3	145.6	81.3	143.7 ± 1.07	78.0 ± 2.62	80.7 ± 2.01
Rural nonagriculture	29	139.7	143.5	79.7	144.1 ± 1.15	80.6 ± 2.82	82.7 ± 2.16
Experiment means		141.2	145.4				
Significance of differences between group means					$P < .01$	$P < .01$	$P < .01$
GIRLS 108–155 months of age							
Private school urban	17	130.9	145.1	83.5	147.9 ± 1.65	87.3 ± 3.39	82.5 ± 2.54
Rural owner	35	138.3	146.7	77.8	146.4 ± 1.11	77.3 ± 2.30	74.7 ± 1.71
Rural tenant	42	139.0	143.4	77.5	142.8 ± 1.02	76.6 ± 2.10	79.1 ± 1.57
Rural nonagriculture	36	137.9	143.5	77.7	143.3 ± 1.10	77.5 ± 2.28	79.1 ± 1.67
Experiment means		137.5	144.5				
Significance of differences between group means					$P = .02$	$P = .06$	$P = .05$

* In the case of boys, the means were adjusted for age 141.2 months, and for height 145.4 centimeters.

In the case of girls, the means were adjusted for age 137.5 months, and for height 144.5 centimeters.

levels of nutritional adequacy dependent upon different dietary patterns. Further work will be needed to establish the validity of this hypothesis.

METHODS

For the purpose of this study of methodology, measurements were made of the heights and weights of a number of rural school children who had attained their ninth birthday and not yet attained their fourteenth birthday. Over this age span the regression of height and weight on age is approximately linear. These rural children, numbering 112 boys and 113 girls, were divided into three groups according to the occupations of their parents: those whose families

were farm owners, those whose families were farm tenants, and a residual group whose families were not engaged exclusively in agriculture. In addition and for contrast, a fourth group was studied consisting of 25 boys and 17 girls from a private school in an urban area. The four groups of children measured were chosen for a study in methodology and are not to be regarded as typical samples either of private school children or of rural children living in this area.

The statistical method used in analyzing the data of this study was the method of covariance (Snedecor, 1946), and the results of the analysis are presented in the tables.

TABLE 2

Adjusted group mean measurements, differences, and their significance
Private school urban group vs. rural group

	ADJUSTED GROUP MEANS		DIFFERENCE BETWEEN MEANS	t AND SIGNIFICANCE
	Private school	Rural		
BOYS 108–167 months of age (private 25, rural 112)*				
Height adjusted for age 141.2 mo., cm.	150.3	144.3	6.0	$t = 4.32$ $P < .01$
Weight adjusted for age 141.2 mo., lbs.	99.4	79.4	20.0	$t = 5.71$ $P < .01$
Weight adjusted for age 141.2 mo., height 145.4 cm., lbs.	91.5	81.2	10.3	$t = 3.57$ $P < .01$
GIRLS 108–155 months of age (private 17, rural 113)*				
Height adjusted for age 137.5 mo., cm.	147.9	144.1	3.8	$t = 2.11$ $P = .04$
Weight adjusted for age 137.5 mo., lbs.	87.3	77.1	10.2	$t = 2.79$ $P < .01$
Weight adjusted for age 137.5 mo., height 144.5 cm., lbs.	82.5	77.7	4.8	$t = 1.78$ N.S.

* Number of children in groups.

RESULTS AND DISCUSSION

As will be noted from Table 1 the observed mean heights and weights of the eight groups of children were adjusted for age, and in addition the mean weights were adjusted for both age and height, utilizing for this purpose the mean age and the mean height of all boys and all girls studied. Fiducial limits were calculated for these adjusted means and the significance of the differences among the adjusted group means was determined.

Table 2 presents the adjusted group mean measurements of the private school urban boys and girls as compared with those of all three rural groups, together with tests of significance of the differences between these mean measurements.

This table demonstrates that in these particular samples of children, in the case of the boys the mean height adjusted for age of the private school boys was 6 centimeters greater than the adjusted mean height of the boys of the three rural groups. Group mean weights adjusted for age showed that the private school boys were 20 pounds heavier than the rural boys, and when weight was adjusted for both age and height (a process which removes the increase in weight due to height as well as age) the private school boys were 10 pounds heavier than the rural boys. The tests of significance (last column, Table 2) show that when the effect of age is discounted the private school boys were significantly taller and heavier than the rural boys, and when the effect of height as well as age is discounted the private school boys are still significantly heavier than the rural boys.

Turning to the comparison of adjusted mean measurements in private school and rural girls (Table 2) we find less striking differences than was the case with the boys. When the effect of age is discounted the private school girls average 3.8 centimeters taller and 10.2 pounds heavier than the rural girls, and the significance of these differences is indicated in the table. When weights are adjusted for both height and age the private school girls are 4.8 pounds heavier than the rural girls, a difference which has not been shown to be significant in the samples here employed. The possibility of a significant difference might be investigated further using larger samples. It is interesting to speculate why the girls showed less striking differences than the boys between private school and rural groups in adjusted mean heights and weights.

A similar analysis was made of the differences in the adjusted mean measurements of the rural owner boys and girls as compared with the rural tenant boys and girls. The small differences found in adjusted means were not significant except in the case of the one comparison in the girls of heights adjusted for age where the rural owner girls were 3.6 centimeters taller than the rural tenant girls ($t = 2.38$, $P = .03$).

SUMMARY AND CONCLUSIONS

This study indicates that covariance can be applied to the analysis of differences in mean measurements of height, weight, and presumably other body dimensions of small groups of school children from varying socio-economic backgrounds. It is an efficient and appropriate tool for this purpose. In further studies we will seek to confirm and extend this concept of methodology, as well as to determine with other techniques the extent to which these differences in body size can be attributed to differences in dietary pattern and nutritional status.

REFERENCES

MEREDITH, H. V. 1941. Stature and Weight of Children of the United States. Am. J. Dis. Child. 62 (5): 909–932.

SNEDECOR, G. W. 1946. Statistical Methods Applied to Experiments in Agriculture and Biology, 4th Ed. Iowa State College Press, Ames, Iowa.

A NEW GROUP OF ORGANISMS RELATED TO ACTINOMYCES

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One of the characteristics of the Actinomycetales is the absence of motile flagellated cells. By using the technics which are commonly employed in isolating the saprophytic Chytridiales, more than a dozen forms have been found and isolated in pure culture, which clearly belong in the Actinomycetales, but produce zoosporangia and zoospores. These organisms appeared in dishes which were baited in the usual way for water molds and chytrids, and their discovery was purely an accident.

Each bit of soil, about a gram or less, was put in a sterile Petri dish, and after half filling each dish with sterile charcoal water, bait in the form of cooked half hemp seeds, small pieces of boiled *Paspalum* grass, and filter paper was added. After a few days the larger water molds and chytrids appeared on the bait, but instead of discarding the old dishes containing the soil, new bait was added from time to time. On February 13, 1948, in examining a piece of filter paper which had been in one of the dishes for several weeks an unusual type of organism was observed consisting of minute globose to subglobose bodies attached to the filter paper fibers by short delicate stalks. These spheroidal bodies formed as a rule in enormous quantities in shallow cultures at the surface of the water, and resembling minute grains of sand had been passed over as agglomerations of bacteria or minute sand grains, until on the above date it was noticed that they were attached to delicate threads, and gave rise to zoospores in zoosporangia. Since this first type was found in soil from the Philippine Islands a total of eleven other isolations and purifications have been made from soil from various locations.

These forms grow very slowly. In water cultures on grass leaves a well developed growth, visible with a lens, appears after ten days or two weeks. In soil dilutions in Jensen's dextrose casein agar these new forms appear after eight to twelve days as tiny spheres a millimeter or less in diameter, while typical *Streptomyces* has attained a growth of at least a centimeter.

The mycelium on boiled *Paspalum* grass leaves is richly branched and very delicate. All the forms or species now in culture turn the leaves in water cultures reddish or pinkish. One of the species, when grown on pieces of boiled *Paspalum* grass leaves in water, forms short, twisted aerial hyphae visible under the microscope, but none has been found so far which forms the abundant tufts of aerial mycelium or the beautiful, symmetrically coiled aerial hyphae of certain species of *Streptomyces*.

These new forms have now been cultured on most of the usual agar media used for *Streptomyces*, as Czapek's solution agar with and without glycerine,

Krainsky's dextrose asparagin, calcium malate, dextrose casein, nutrient agar for bacteria, potato dextrose agar, Drechsler's agar for *Actinomyces*, etc., and on gelatin, and produce the same types of growth on agar and gelatin as have been described particularly by Jensen (1930–31) for the genus *Micromonospora*. On certain agars these new forms produce a very remarkable and characteristic growth with a smooth, convoluted or nodulose, wet, slimy surface instead of the floccose surface characteristics of most species of *Streptomyces*. Some species on certain agars form a tough, cartilaginous surface growth. A thin radial section, through the growth of collection number P15 from surface to the bottom of the dish, shows that the tough cartilaginous surface growth is composed of a dense layer of vertical hyphae between which are interlaced scattered, horizontal hyphae, while below this dense layer are loosely arranged threads which extend for the most part horizontally throughout the agar, and which in the marginal region extend considerably beyond the surface layer. The vertical hyphae arise from the horizontal hyphae, and hence the surface layer is much thicker at the center than near the margin. I have also noticed a somewhat similar pattern of growth for the intramatrical hyphae of certain species of *Streptomyces*.

The most remarkable feature of these unusual forms is the production of sporangia with zoospores. On boiled *Paspalum* grass leaves and certain other culture media in water the sporangia appear after about ten days in all the isolates so far obtained except one (H11G), while only a few form on agar. The sporangia as a rule are formed on leaves close to the surface of the water on short stalks, which project up above the surface a short distance in the air. Such sporangia may be easily broken off with or without part of the stalk to be disseminated by wind or water. Sporangia are also formed beneath the surface in some species on lateral as well as terminal branches and then show a rather striking, if superficial, resemblance to the more tenuous members of the Cladochytriaceae as *C. tenue*. Sporangia, mature in size but with undifferentiated spores, may remain in a resting condition for weeks, or until they are disturbed by a change of water or by mounting them on a slide. Such a change induces spore formation in from a half to one hour. Before spore formation starts, the protoplasm of the sporangium is evenly and finely granular with many small vacuoles dispersed throughout. Next one can see numerous small pale or yellowish globules, and then the spores become evident, each containing one of the globules. At this stage in some species the spores show a distinct spiral arrangement within the sporangium. It is very interesting to compare some of Drechsler's (1919) figures as 41 and 51, in which he shows the conidia formed in compact coils, very suggestive of the arrangement of the zoospores in the forms here discussed. In some species the zoospores are set free by the gradual but complete dissolution of the sporangial wall, in others part of the wall dissolves and part remains, and in others an irregular opening is formed in the wall through which the spores emerge. When set free the spores swim actively for a few minutes to several hours. The zoospores have been observed under dark field and with a phase microscope, but very little could be made out about the flagella

while the spores were in motion or even while they were quiet. Sometimes as a spore slowed down, a single flagellum could be seen with a thick basal part and a thin end part attached at the front of the spore, but bending backward as the spore swam. In one of the first mounts examined under the dark field and phase microscope there were swimming zoospores of the large chytrid *Karlingea rosea*, the flagella and thin whip lashes of which were remarkably clear. It is of interest to note that in all the chytrid zoospores I have examined with the dark field the flagella have been very distinct even on the most minute spores. If killed with 1% osmic acid fumes and stained with gentian violet about one out of five of the spores showed a thick basal flagellum and still fewer showed the tenuous portion. Loeffler's stain as used by me (1941) failed to reveal any structures that could be identified as flagella. While the exact nature of the organs of locomotion remains obscure it appears quite certain that they are not like those of any of the aquatic Phycomycetes, but rather are more like those found in certain bacteria.

In one of the species isolated from soil in Chapel Hill (D.S. 34) sporangia are formed on some agars and on *Paspalum* grass leaves in water. When mature, and disturbed as by mounting on a slide in water, the sporangial walls are partly hydrolyzed and the spores are set free in enormous quantities, but are non-motile. So far as observations have gone, this is the only type of spore produced by the present form. On grass leaves in water and on certain agars this species produces aerial hyphae much as in *Streptomyces*, and it seems very likely that this is a connecting form between the sporangial species with zoospores and *Streptomyces*.

Most bacteriologists treat the Actinomycetales as an order in the higher bacteria. In Waksman's and Henrici's recent classification three families are recognized, the Mycobacteriaceae with rudimentary or no mycelia at all, and then the two families, Actinomycetaceae and Streptomycetaceae, both with branched mycelia. In the first of these two no conidia are formed, and the vegetative mycelium divides by segmentation into bacillary or coccoid arthrospores, while in the second the vegetative mycelium is usually not divided into arthrospores, and conidia are formed on proper media. This latter family, the Streptomycetaceae, contains two genera: *Streptomyces*, in which conidia are formed in chains on aerial hyphae, and *Micromonospora*, in which conidia are formed singly on the ends of hyphae, or in small clusters, but not in chains. In *Streptomyces* a very characteristic aerial mycelium is formed, while in *Micromonospora* aerial mycelium is lacking or produced very sparingly. Thus the surface of *Streptomyces* on agar has a myceloid or dusty appearance, while the surface of *Micromonospora* usually is wet and slimy. From vegetative characteristics alone the sporangial forms seem closest to *Micromonospora*. This genus is characterized by Jensen (1930–31) as follows:

Actinomyces-like organisms, forming a mycelium of delicate, non-septate hyphae, 0.3–0.8μ thick, without aerial mycelium (or traces, then without spores), but producing spores singly on the distal ends of short lateral branches of the vegetative mycelium; spores spherical to oval, 1.0–1.2 $\times$ 1.2–1.5μ. Mycelium

and spores Gram-positive, not acid-fast. Aerobic organisms, most frequently met with in soil. The type species is *Micromonospora chalceae* (Foulerton).

In none of the sporangial forms were the minute spores supposedly so characteristic of *Micromonospora* formed. Could it be possible that the sporangia had been overlooked by former investigators of this genus? To test this possibility I tried to get authentic cultures of this genus from various workers in this group, but so far have been unable to get cultures of *M. chalceae* or *M. fusca*, two of the better known species. Through the kindness of Dr. S. A. Waksman I have been able to study *Micromonospora* #3450, which produces abundant small spores but does not form sporangia on any of the culture media tried. I have isolated from the soil several species which obviously belong to the genus *Micromonospora*, but none of these have produced sporangia, though some produce microspores in vast quantities in *Botrytis*-like clusters. There can be no possibility of confusing the conidia in *Micromonospora* with the sporangia in the present group, since the spores never exceed 2μ in diameter while the sporangia vary from 5–20μ thick. These forms which bear sporangia are closely related both to *Streptomyces* and *Micromonospora*, but are so strikingly distinct in having zoosporangia and zoospores as to make necessary placing such species in a new genus.

The present paper is intended, however, merely to announce the discovery of sporangia and zoospores in the order Actinomycetales. The detailed description of the genus and the several species on which it is based will be published later.

The writer is deeply indebted to W. Lane Barksdale for the soil samples from which the first isolations were made.

LITERATURE CITED

JENSEN, H. L. 1930-31. The genus *Micromonospora* Ørskov—a little known group of soil microorganisms. Proc. Linn. Soc. N. S. Wales **55**: 231–248.

DREHSLER, CHARLES 1919. Morphology of the genus *Actinomyces*. Bot. Gaz. **67**: 65–83, 147–168, pl. 2–9.

COUCH, J. N. 1941. The structure and action of the cilia in some aquatic Phycomycetes. Amer. Jour. Bot. **28**: 704–713.

WAKSMAN, S. A., AND HENRICI, A. T. 1943. The nomenclature and classification of the Actinomycetes. Jour. Bact. **46**: 337.

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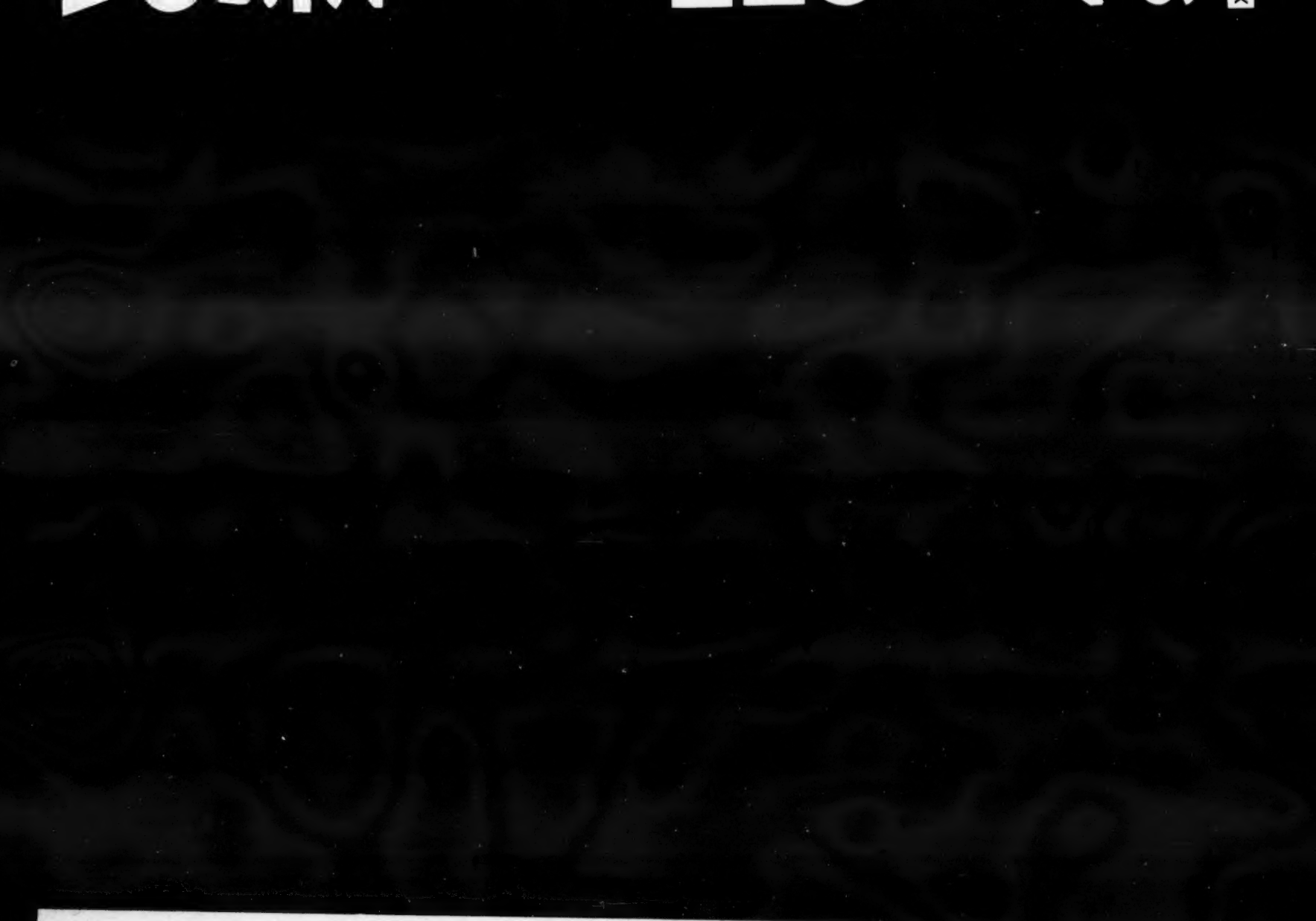
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